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JPRS-JST-87-019

11 JUNE 1987

SCIENCE & TECHNOLOGY

JAPAN

CONTENTS

METALLURGICAL INDUSTRIES

/12223

HIGH-PURITY POLYCRYSTALLINE DIAMOND TECHNOLOGY REPORTED

Tokyo KINO ZAIRYO in Japanese Feb 87 pp 5-12

[Text] In recent years, the spread of polycrystalline diamond tools has been remarkable, but now we are entering a new situation with respect to dealing with cost reductions, new uses, and new materials. Toshiba Tungaloy Co., Ltd., has developed (on commission from the RDCJ (Research Development Corporation of Japan) a new technology in order to meet the market trend. This new technology is used to manufacture at one time, a large number of high-purity polycrystalline diamonds which can be used to work cut-resistant materials with high efficiency. This manuscript describes the outline of this development work and resulting product.

1. Preface

Polycrystalline diamond tools are better than single crystal diamond tools in toughness, wear resistance, form freedom, quality stability, etc. They have spread as cutting tools, wire drawing dies, civil and mining tools, dresser, since they were commercialized by GE Corporation in the United States for the first time in 1973. They have been used in the field of hard metal tools as well as having replaced grinding and single crystal diamond tools as cutting utensils. Polycrystalline diamond tools cost more than hard metal tool initially, but are superior to these hard metal tools in longevity and quality of machined surfaces. Recently, a drill with a very small diameter has been developed. A polycrystalline diamong tip is incorporated in this drill.

In accordance with the development of the above use, expectations are increasing in the market that cut-resistant materials, such as high silicon aluminum alloy, FRM (fiber reinforced metal), new ceramics, etc., can be worked with high efficiency. In addition, the reduction in cost of polycrystalline diamond tools has been increasingly required. In order to meet the market trend, Toshiba Tungaloy Co., Ltd. has promoted the "Development of Technology for Manufacturing High-Purity Polycrystalline Diamond" on commission from the RDCJ based on research results obtained by the NIRIM (National Institute for Research in Inorganic Materials) of the STA (Science and Technology Agency), and has successfully completed the development work.

In this development work, the company aimed at developing a technology for manufacturing at one time a large number of large-diameter polycrystalline diamonds in order to reduce costs, as well as a high-purity polycrystalline diamond which could be used to cut 20 percent-Si-Al alloy, etc., with high efficiency. The purity of conventional products is 85 to 95 vol percent, and about two sheets of sintered bodies with a diameter of about 12 millimeters can be manufactured by using conventional technologies of the company. Thanks to the success of the above development work, several sheets of polycrystalline diamonds with a purity of about 97 percent and a diameter of 18 millimeters can be manufactured at one time. (Polycrystalline diamond used as a cutting tool is formed as a composite material in which a sintered diamond layer with a thickness of 0.5 to 1 millimeter is laminated on a trapezoid of a hard metal, because the polycrystalline diamond must be brazed, etc.)

The following is the outline of the above development work and developed products.

2. Development of Ultrahigh Pressure Sintering Unit

Diamond sintering production needs a unit which can stably generate a pressure of more than 60,000 normal atmospheres (60 tons per square centimeter) and a tempoerature of more than 1,500 degrees centigrade. A flat belt type ultrahigh pressure unit developed by the NIRIM was adopted as this unit to sinter diamond. This unit is one of the further developed versions of the belt type ultrahigh pressure unit made by GE Corporation, and possesses the following features: 1) it can stably generate ultrahigh pressure and temperature with little danger of blow-out (sealed pressure leaks explosively), 2) the volume of a large test piece room can be taken, because the compression stroke of a piston is large, 3) in particular, it is possible to carry out multilayer sintering work. Also, the following items are devised: 1) shape of cylinder and piston of a truncated cone, usually called an "Anvil," 2) gasket (pressure sealing member), 3) high pressure vessel.

Figure 1. shows a typical drawing of the flat belt type ultrahigh pressure unit. The principle is the same as that of the belt type ultrahigh pressure unit. That is, a carbon heater and a test piece are incorporated into a high pressure vessel consisting of solid pressure media, the high pressure vessel is mounted on a disklike cylinder together with a compressible gasket and an electrode plate, ultrahigh pressure is generated by pressurizing the high pressure vessel through the hydraulic press and a piston of the upper and lower truncated cones, and the high pressure vessel is heated by electrifying a heater through the piston. The piston and cylinder core are made of hard metal, and are reinforced by being press-fitted onto multilayer steel rings. Generally, the cylinder core is made of hard metal, but it is possible to use high speed steel, which is less expensive than hard metal, in the cylinder core. This can be cited as one of the features of the flat belt type ultrahigh pressure unit. The press-fitting operation is an important technology which affects the life of the

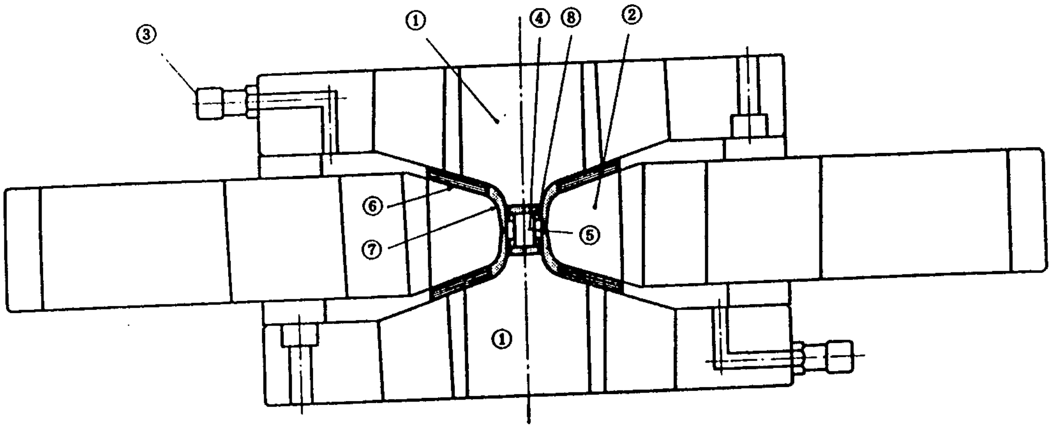

Figure 1. Structure of Flat Belt Type Ultrahigh Pressure Unit

Key:

1. Hard metal anvil
2. Hard metal die
3. Inlet and outlet of cooling water
4. Reaction room
5. Graphite heater
6. Laminated paper gasket
7. Pyrophyllite gasket
8. Electrical ring

unit, and it requires the accumulation of considerable technology. The company has long experience in press-fitting of ultrahigh pressure units, but has gained a great deal of knowledge based on theoretical analyses from the NIRIM. The conical angle is slightly smaller than that of the belt type ultrahigh pressure unit. The outside of the gasket consists of laminated paper, and the inside of pyrophyllite ($Al_2O_3.4SiO_2.H_2O$) powder compact. The most important feature of the flat belt type ultrahigh pressure unit is that the gasket is double-structured using laminated paper. The high pressure vessel consists of a salt-zirconia mixing powder compact and a steel ring. Pyrophillite and salt are used as a gasket material and as a pressure medium well known in the field of ultrahigh pressure technology. Pyrophillite has the proper fluidity and high pressure sealing capacity. It is also used as a pressure medium. Usually, natural rock mined in South Africa is used as a gasket material, but the company has succeeded in using domestically produced and formed powder. Salt is used as a pressure medium, because it is soft, has excellent hydrostatic pressure and insulation properties, and the amount of volume reduction caused by decomposition or phase transformation under the ultrahigh pressure and temperature is small. Zirconia is added to salt to increase the heat insulating properties. These parts are throwaway goods, but the number needed is large and they require accuracy, and the ratio accounted for by them in terms of cost is large. Therefore, the problem is how to reduce the cost in the future.

Before introducing this unit into the company, it has made some improvements in the unit considering basic specifications stipulated by the NIRIM so that the unit can be used smoothly to manufacture products. Important improvements are as follows: 1) a balance between horizontal retaining of a cylinder and longitudinal pressuring to the cylinder has been attained by developing an automatic mechanism for the operation of the unit and by adopting a link type cylinder retaining mechanism developed independently by the company, 2) devices and experience gained by the company as a powder metallurgical manufacturer have been used to granulate powder, increase the fluidity of the powder, select the binder and parting agent, and design the mold and molding machine, because parts must be molded with high density and accuracy, 3) a press has been modified for use. The press has long been used by the company for the purpose of synthesizing diamond powder.

The unit developed by the company can stably generate a pressure of 70,000 normal atmospheres and a temperature of 1,600 degrees centigrade. Figure 2 shows an example of a pressure calibration curbe, and Figure 3 shows that of a temperature calibration curve, respectively. The pressure at normal temperatures is measured with a pressure sensor (the crystalline structure is changed by pressure, and the electrical resistance changes discontinuously), such as bismuth, thallium, barium,etc., and that at high temperatures is checked by synthesizing diamond, etc. The temperature is measured directly by inserting a thermocouple into the unit. But when the unit is operated normally, it will be controlled with hydraulic pressure and electric power due to the correlation between pressure and temperature. The pressure generation and temperature change depending on the composition of parts or test pieces. The pressure generation efficiency is in tens of percent, with the remaining pressure being used to compress the gasket and high pressure vessel and works to deal the ultrahigh pressure generated in the test piece section. The pressure generation efficiency is decided with consideration given to the stress distribution of the entire unit.

3. Development of Sintering Technology

3.1 Principle of sintering of diamond

Figure 4.[1] shows a state of pressure-temperature of carbon. From the thermodynamic standpoint, diamond exists unstably under a pressure of less than about 16,000 normal atmospheres, even at normal temperatures. Actually, it seems that diamond exists stably, because it exists metastably, but when the temperature rises, the diamond will be transformed into graphite which exists stably by nature. (The transformation of diamond into graphite will start at a temperature of about 1,500 degrees centigrade in a vacuum,[2] and will start at about 600 or 700 degrees centigrade in an oxidizing atmosphere[3] in the presence of ferrous metal[4], etc. Diamond will burn at a temperature of more than 650 degrees centigrade in the atmosphere. But in the case of

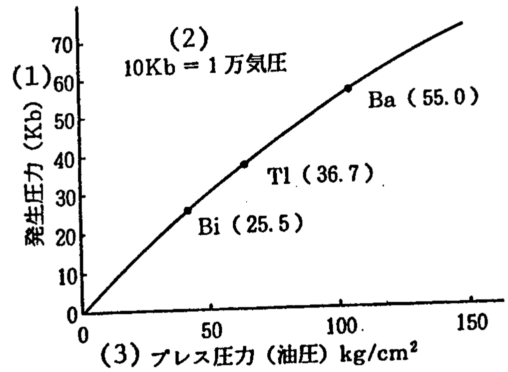

Figure 2. Example of Pressure Calibration Curve

Key:
1. Pressure generated (Kb)
2. 10 Kb = 10,000 normal atmospheres
3. Press pressure (hydraulic pressure) kilograms per square centimeter

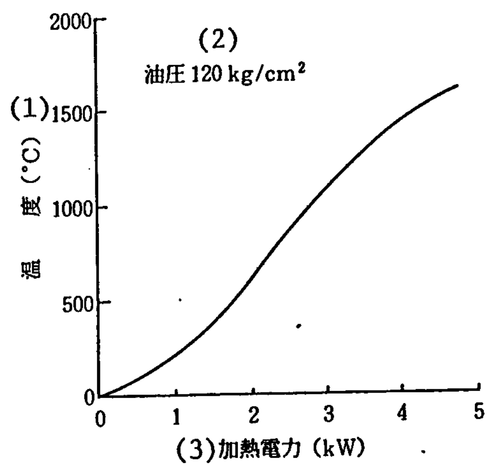

Figure 3. Example of Temperature Calibration Curve

Key:
1. Temperature (degrees centigrade)
2. Hydraulic pressure : 120 kilograms per square centimeter
3. Heating electric power (kilowatts)

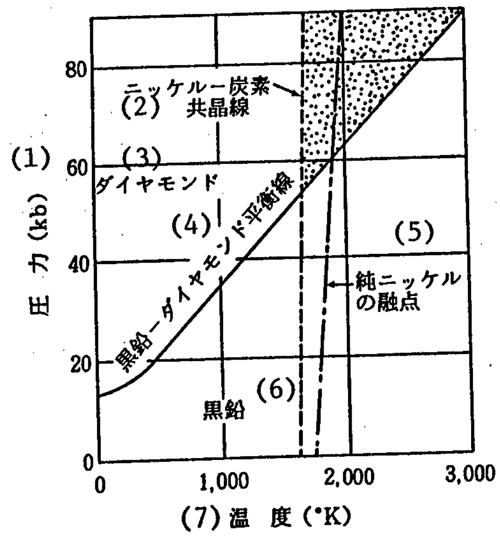

Figure 4. Graphite-Carbon State Drawing and Nickel-Graphite Eutectic Line (10 Kb = 10,000 normal atmospheres)

Key:

1. Pressure (kb)
2. Nickel-carbon eutectic line
3. Diamond
4. Graphite-diamond equilibrium line
5. Melting point of pure nickel
6. Graphite
7. Temperature (Kelvin]

diamond powder, the combustion temperature depends on particle size.) For these reasons, it is necessary to sinter diamond within an area in which it is not transformed into graphite. It is difficult to cause the diffusion of atoms and the plastic fluidity in diamond, because diamond has high hardness, and is a covalent bond crystal with a high melting point. It is said that, for example, a pressure of 85,000 normal atmospheres and a temperature of about 2,200 degrees centigrade are required to sinter diamond without any use of a sintering assistant.[5] These conditions are not economical at the present technical level, because they take a great deal of money. Accordingly, a ferrous metal (alloy) solvent is used as a sintering assistant in the same manner as in the synthesis of diamond according to a solvent-catalyst method. When diamond is synthesized, graphite will melt into solvent metal at ultra-high pressure and high temperature, and will be crystallized as a diamond. When diamond is sintered, the surface of diamond particles or a part of these particles will be melted into solvent metal, and will be crystallized as a diamond. At this time, diamond particles will combine with each other. It is said that the driving force of reactions caused by synthesizing diamond can be expressed as a solubility difference based on the difference between

the chemical potential of graphite and that of diamond. It is considered that the driving force of reactions caused by sintering diamond can be expressed as a solubility difference based on the difference of the curvature radius of the surface among diamond particles. It is possible to sinter diamond to which graphite has been added, but it is very difficult to obtain useful polycrystalline diamond by simultaneously synthesizing only graphite. The diamond synthesizable area is a section between a graphite-diamond equilibrium line and a solvent (nickel)-graphite eutectic line shown in Figure 4. According to this figure, the lower limit conditions of synthesis are a pressure of about 52,000 normal atmospheres and a temperature of 1,400 degrees centigrade. The case of cobalt being used as a solvent is almost the same as that above. Conditions in the sintering case are slightly more severe than those in the synthesizing case. The sinterable area is slightly smaller than the synthesizable one. The appropriate sinterable area is further narrower than the sinterable one. when cobalt is used as a solvent, a pressure of about 60,000 normal atmospheres and a temperature of more than 1,500 degrees centigrade are required as lower limit conditions of synthesis.

Diamond sintering is very similar to that of hard metals (WC-Co) in that it involves liquid phase sintering according to melting and crystallization. The difference between it and that of hard metal is that the strength is increased by combining diamond particles with each other. In the case of hard metal, the wettability between WC and Co is good, Co satisfactorily circulates around WC and functions as a binder, and the strength increases. But in the case of diamond, diamond particles are combined with each other because the wettability with Co is bad. After sintering Co, it remains in the shape of a pool in a part of the grain boundary of the diamond particles. This is not a binder, but an includion phase. [Note: It seems that the diamond sintered compact in which diamond particles are combined with each other is internationally called "PCD (polycrystalline diamond)," and is distinguished from the sintered diamond in which diamond particles are not combined with each other. In addition, this sintered diamond is combined with metal, cermet, ceramics, etc. Natural polycrystalline diamond exists in the world, but its output is very small. Single crystal diamond has the cleavage along the octahedral plane (111 plane), but polycrystalline diamond has no cleavage and is resistant to impact, because it has random crystal direction. Also, it has no directional properties in hardness and wear resistance.] Co is indispensable during sintering, but afterward it will remain in a part of the grain boundary, will lower the heat resistance of sintered compacts due to the difference of the thermal coefficient of expansion between diamond and it, and will reversely promote the transformation of diamond into graphite as well as reducing the area in which diamond particles are combined with each other, and will prevent the strength from increasing. In addition, it will cause a decrease in wear resistance due to reactions with materials to be machined. Therefore, in order to cut the high silicon aluminum alloy, new ceramics, etc., it is necessary to minimize the amount of this residual Co.

3.1 Sintering Technology

The development of ultrahigh pressure units is the most important factor because, generally speaking, the completion degree of ultrahigh pressure technologies is not high. But even if there is a unit which can be used to

obtain necessary pressure and temperature, of course, polycrystalline diamond will not be obtained only by using this unit. The basic method of manufacturing polycrystalline diamond is to pack the diamond powder, solvent metal, hard metal trapezoid metal, etc., in metallic capsules with high melting point and to sinter these capsules in the test piece room of the high pressure vessel. (The hard trapezoid metal is integratedly sintered in order to simplify the brazing work during tool manufacturing.) Also, there are factors in the method of using solvent, method of packing such materials, consideration to residual gas, etc. The technology developed independently by this company has been used as its basic sintering technology. The heater and test piece room are deformed under ultrahigh pressure and high temperatures. In addition, cracks may get mixed with sintered compacts, because the ultrahigh pressure and high temperature rapidly return to normal pressure and temperature. Therefore, it is necessary to take measures against these problems. In order to do so, generally speaking, it is important to solve the following problems involving hydrostatic pressure. The problems are 1) structure of the high pressure vessel, 2) structure of the test piece room, 3) method of packing materials in the test piece room, 4) method of raising the temperature and pressure, and 5) method of lowering the temperature and pressure.

Other problems were caused by expanding the diameter of sintered compacts and multi-layering these sintered compacts. Therefore, these problems had to be solved. First the previously mentioned unit is unsatisfactory as a productive sintering unit, because it is basically designed to synthesize diamond. Accordingly, it was necessary to make technical improvements in this unit. That is, the structure of the heater and that of the test piece room had to be modified to enhance the soakability in the heater, because conditions for sintering diamond are more demanding than those for synthesizing it. As a result, it has become possible to actually multi-layer and sinter diamond. Also, it was necessary to study anew the methods of selecting heater materials, packing test pieces, increasing and decreasing the temperature and pressure, etc., because the following problems are liable to occur. The problems are 1) electric current trouble caused by damage of the heater, 2) leakage of pressure medium caused by damage of capsules, 3) deformation of test pieces, 4) ingress of cracks in sintered compact.

It has become possible to manufacture a high purity polycrystalline diamond by selecting diamond powder as a raw material and devising sintering conditions, etc., as well as using the above-mentioned sintering technologies.

4. Development of Working Technology

In order to offer polycrystalline diamond extracted from a sintering unit as a tool manufacturing material to users, the surface of this diamond must be polished, because the diamond is put in a metallic capsule or is deformed. However, the diamond is so hard that its surface cannot be polished with the usual diamond-bonded grinding wheel. The higher the purity of the diamond, the more difficult it is to polish the surface. As a result of studying various matters, it has become possible to efficiently work such diamond by using a special-purpose machine. Also, in order to offer such diamond

as a tool manufacturing material to users, the diamond must be broken finely into an optional shape. But, it was difficult to (wire-cut) the high purity diamond, because such diamond has little electrical conduction. When this diamond is cut with laser beams, areas damaged by the laser beams will be considerable. In order to solve this problem, research on a wire-cut using technology was conducted. As a result, it has become possible to electric-discharge-machine such diamond. However, there is room for further improvement in working technology. The working technology will become significant in reducing the cost of polycrystalline diamond in the future.

5. High Purity Polycrystalline Diamond and Cutting Performance

The high purity polycrystalline diamond has a structure in which coarse and fine particles are mixed. The amount of Co remaining in the grain boundary is small. It can be understood that diamond particles are combined. The Knoop hardness is more than 8,000 kilograms per square millimeter, which is close to the hardness of penetrators made of diamond. Therefore, it is difficult to measure precisely such a high Knoop hardness.

Figure 5. shows cutting results of 20 percent Si-Al alloy. The amount of wear is about half that of conventional products. Materials to be machined are attached to the Co phase of the grain boundary of polycrystalline diamond, and the attachment degree of Si is more pronounced than that of Al. It is difficult to grind the high silicon-aluminum alloy, presumably for the following reasons: 1) primary phase Si particles coarsely dispersing in this alloy are hard and abrasive, 2) the wear is promoted by the pressure-connection, separation, and damage caused by chemical reactions between Si and Co. Therefore, it can be said that the high purity polycrystalline diamond with a small amount of residual Co is advantageous from the above standpoint.

Diamond tools have heavy chemical wear (diffusion wear) against iron based-materials. For this reason, usually sintered compact tools are not used to work such materials. But, depending on conditions, these sintered compact tools are effective for working cast iron, because the amount of carbon contained in cast iron is large and reactions are restrained. High purity polycrystalline diamond is also promising for this use.

Features of this product (high purity polycrystalline diamond) developed by the company are as follows: 1) it has high purity, high hardness, and high wear resistance, 2) it can be used to work 20 percent Si-Al alloy, ceramics, etc., with high efficiency, 3) it can be used in tools with a long cutting edge, because it has a large diameter.

6. View for the Future

We have given an outline of the development work and developed product up to now. In the future, we want to reduce the cost of the product and parts by raising the yield and improving the working technology, to develop a

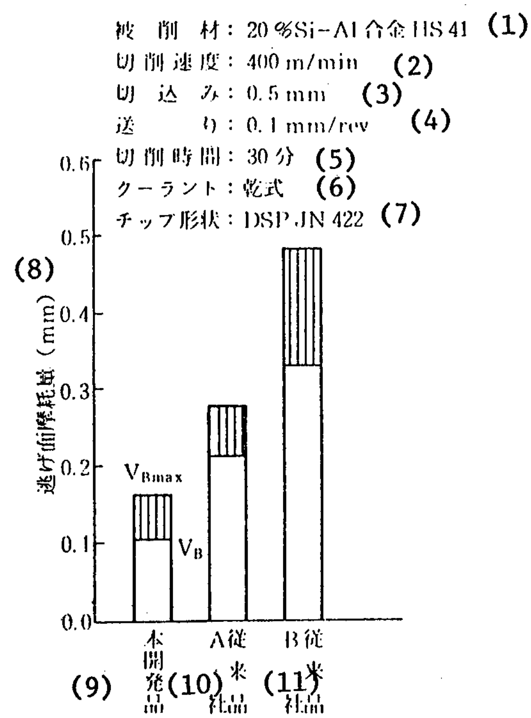

Figure 5. Cutting Results of 20 Percent Silicon-Aluminum Alloy

Key:

1. Material to be machined : 20 percent Si-Al alloy HS 41
2. Cutting speed : 400 meters per minute
3. Grain depth of cut : 0.5 millimeter
4. Feed : 0.1 millimeters per revolution
5. Cutting time : 30 minutes
6. Coolant : drying type
7. Shape of chips : DSP JN 422
8. The amount of flank worn (millimeter)
9. Product developed by Toshiba Tungaloy Co., Ltd.
10. Conventional product made by company A
11. Conventional product made by company B

polycrystalline diamond with a larger diameter, and to increase the number of sintering layers. Also, we want to develop products which meet the market needs. It seems that various product series will be made in accordance with use in the same way as those of hard metal tools, because polycrystalline diamond tools have been brought to the stage in which their materials can be designed. In addition, polycrystalline diamond, in which no solvent is used or is included, has 100 percent purity. Such polycrystalline diamond is an ultimate tool and is an ideal product for developers. We are sure that it will be put to practical use in the future by improving the above-mentioned unit and devising the sintering technology.

BIBLIOGRAPHY

1. F.P. Bundy, et al. J. Chem. Phys., 35, 383 (1961).

2. T. Evans and P.F. James : Proc. Roy. Soc. Lond. A277 260 (1964).

3. T. Evans and C. Phaal : Proc. Fifth Biennial Conf. on Carbon, Vol 1 p 147 (1961).

4. Yoshinobu Tanaka, Naoya Igawa, and Takeshi Tanaka : Precision Machine, 36, 8, 578 (1970).

5. H.T. Hall, Science, 169, 868 (1970).

20143/8309
CSO: 4306/7552

LARGE SCALE COMMUNICATIONS SATELLITE PLANNED

OW231033 Tokyo KYODO in English 0938 GMT 23 Mar 87

[Text] Tokyo, March 23 KYODO--A government advisory council on communications technology Friday submitted to Posts and Telecommunications Minister Shujiro Karasawa plans for the development of a geostationary platform-style communications satellite, ministry officials said.

The proposed large-scale space platform, scheduled for completion early next century, will be equipped with a number of large antennas to relay signals emitted by a variety of communication media ranging from car telephones to international data transmission systems, the officials said.

The ministry envisages three of the communications satellites in place over Japan, Southeast Asia and the South Pacific soon after the year 2000.

The council's plan gave no indication of the projects cost.

The first phase of the satellite development program will involved a number of preliminary experiments to be conducted aboard a space platform scheduled for joint development by scientists from Japan, the United States and the European Community in the mid-1990's, according to the plan.

In step two of the program, a small-scale (3-ton) platform-style satellite will be used to conduct further practical experiments in the latter half of the next decade.

The final phase will involve the satellite's structural assembly and the development of essential components such as relays and antennas.

Larger than satellites previously developed in Japan, the proposed communications satellite will be assembled in a low 500-kilometer orbit before gradually being moved out to a stationary orbit of 36,000 kilometers.

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CSO: 4307.021

SPACE INDUSTRY SHOWS STABLE GROWTH

Tokyo AEROSPACE JAPAN-WEEKLY in English 13 Apr 87 pp 6-8

[Text]

Japan's space industry earned ¥197.5 billion in sales during FY 1985, according to the statistics compiled by the Society of Japanese Aerospace Companies (SJAC). The FY 1985 sales hit an all-time high level, representing a 33.7% increase from the previous fiscal year.

The Japanese space industry has been showing stable growth. In particular, sales of space utilization system increased three times as much as the previous fiscal year.

In FY 1986, on the other hand, SJAC forecasts that the sales will decrease by about 12.5% to ¥172.7 billion because of declining sales of satellites and ground facilities.

The 33.7% rise in the FY 1985 sales is attributable to the H-I rocket developed by the National Space Development Agency of Japan (NASDA) and the related facilities and equipment delivered before launching in the summer of 1986.

However, the sales related to the Space Shuttle and data communications/processing/analysis declined from the previous fiscal year. The highest increase in sales was scored by space utilization systems. This was followed by components of rockets and satellites (up 54%), rockets (up 48%) and ground facilities (up 37%).

Of the total sales, domestic demand accounted for 79% and exports for 21%. The domestic demand increased by ¥37.3 billion and exports by ¥12.6 billion. NASDA accounted for 64% of the total sales. With regard to exports, ground facilities for telecommunications satellites accounted for 96%. Imports, on the other hand, amounted to ¥27 billion.

The Japanese space industry's R&D expenses hit an all-time high level of ¥9 billion, up 37% from the previous fiscal year. R&D expenses on components of rockets and

satellites increases three times as much. In terms of monetary amount, R&D expenses on satellites accounted for the largest share or ¥2.7 billion. The number of personnel engaged in the space industry rose 5% to 8,230.

SJAC also forecasted that the sales for FY 1986 would decline 12% to a ¥170 billion level. The sales of satellite components and space utilization systems are estimated to increase by ¥13.9 billion and ¥3.5 billion respectively but other sales are anticipated to slow down. Satellite sales are estimated to decrease by ¥12.7 billion, ground facilities down by ¥23.1 billion and rockets down by ¥5.6 billion.

* Breakdown of FY'85 Space Industry Sales

- Unit: ¥ million -

Category	Sales Amount	Share in %	Change in %
Rockets	48,636	24.6	+ 48.3
Space Shuttle	133	0.1	- 38.1
Satellites	40,513	20.5	+ 16.9
Components for Rockets & Satellites	22,212	11.3	+ 54.1
Ground Facilities	69,000	35.0	+ 37.3
Data Communications/ Processing/Analysis Systems	5,421	2.7	- 19.6
Space Utilization Systems	3,754	1.9	+212.3
Software Development	4,229	2.1	+ 12.2
Data Processing/Analysis	3,628	1.8	- 1.0
Total	197,526	100.0	+ 33.7

/8309
CSO: 4307/019

NIPPI STUDIES COMPOSITE PYLON

Tokyo AEROSPACE JAPAN-WEEKLY in English 13 Apr 87 p 8

[Text]

Japan Aircraft Manufacturing Co., Ltd. (Nippi) has started studying a composite pylon. Conventional pylons are all made of aluminum alloys. It will be first case in Japan to make a pylon with composites.

Using composites, the company expects to reduce the weight of the pylon to about a half, much lighter as compared with conventional pylons. Placing emphasis on this advantage, it expects to propose the composite pylon for the FS-X next support fighter.

Nippi has wide experience in pylon production. It has produced pylons for such aircraft as the F-15 fighter interceptor, the F-4EJ fighter aircraft and the T-2 advanced jet trainer.

/8309
CSO: 4307/019

ASUKA TO ENTER FULL-SCALE FLIGHT TESTS

Tokyo AEROSPACE JAPAN-WEEKLY in English 13 Apr 87 p 9

[Text]

The fanjet STOL research aircraft or "Asuka," developed by the National Aerospace Laboratory (NAL), completed the phase-0 tests at the end of FY 1986 (end of March 1987), centering on airworthiness tests. It will then enter full-scale phase-1 tests in April.

Asuka, since its first flight in October 1985, was tested by Kawasaki Heavy Industries, Ltd. (KHI) until the end of FY 1985 to confirm safety of the aircraft. Under a three-year program from FY 1986, NAL is now conducting engineering tests to demonstrate and establish the STOL technology.

Under the phase-0 of the engineering test program, the aircraft underwent flight tests in CTOL mode in FY 1986 to confirm its airworthiness. As for the STOL capability, NAL conducted simulated takeoff and landing tests up in the air.

Under the two-year phase-1 tests to start in FY 1987, NAL will confirm efficiency of various technology applied to Asuka as well as the STOL technology as a whole. The aircraft will undergo full-scale STOL tests.

Other tests under the phase-1 include those on aerodynamics, flight performance, durability assessment, operation assessment, low-noise operation, high-speed performance, and practical operation assessment at local airports.

/8309
CSO: 4307/019

APPLICATION OF VITAL FUNCTIONS TO ENGINEERING DESCRIBED

Replacing Living Body Structures

Tokyo KOGYO GIJUTSU in Japanese Jul 86 pp 5-7

[Article by Tetsuya Tateishi, chief of Biomechanics Section at Kikai Gijutsu Kenkyusho's System Department, and Makoto Suzuki, senior researcher, same section]

[Text] 1. Introduction

Most body movements of humans and other animals result from coordinated joint actions of the bones and muscles. It is well known that the shape of the thighbone at its top and the internal bone structure at that portion adapts functionally to the load and distortions, which are conveyed to the bone via the thigh joint. In the walking function of humans, the shape of the thighbone and its internal structure at the top has a particular importance affecting function. The roles the skeletal system in a living creature play are not only confined to supporting the weight of its body. Other functions of the bones include alleviation of shocks exerted on the joints and making body movements smooth, production of blood, supply of nutrients and adjustment of internal secretions. Bones are a kind of multifunctional composite material having life-related functions.

In an effort to obtain useful hints from the living body's supportive elements such as the bones regarding their application to the development of the basic design concept of new machines and industrial structural systems, these authors have been advocating the concept of "soft mechanics." The term soft mechanics refers to a "soft" supportive mechanical structure made up of materials, in which the damaged structural element is repaired or strengthened automatically through reproduction or regeneration of the materials as a result of metabolism in the structure. We have been using the term against conventional structures made up of "tough" supportive materials whose intended functions degenerate as material damage accumulates. To realize the development of soft mechanical structures it is necessary to: 1) apply feedback mechanisms in the living body, like the electric-dynamic bone formation mechanism controlling the regeneration of the bones, and the mechanism for conversion of energy in the muscles into would-be soft mechanical structures; 2) develop a material for use in the creation of soft mechanical structures, which can regenerate itself or increase its strength in accordance with the degree of

the load, the frequency of usage, or the change of usage environments, using the repairing material to be supplied in fluid form from an external source; 3) develop a passive soft supportive mechanism which has the capability of absorbing various shocks, like the muscle-bone system in a living creature. It is very difficult to realize the development of the said soft mechanical structures. But this makes the development not only a challenging task but an attractive theme for scientists.

2. Artificial Bones and Joints

In recent years, artificial bones and joints have begun to be used widely in the field of restorative surgery to treat problems in thigh and knee joints. Taking the thigh joint for example, a method to repair the joint developed by a Briton, J. Charnley, around 1960 was quickly used internationally. His method involved the use of metal for the head portion of the thighbone and a high-density polyethylene receptacle for the round thighbone head which was imbedded into the lower portion of the pelvis and fixed there using methyl-methacrylic-system bone cement. However, not long after the method began to be used clinically, problems began to be heard from around the world concerning these artificial joint materials. The problems concerned material wear, damage, and the inflammation of body tissues around the joint. Efforts to develop a better artificial joint have been made, including a change in design and materials of the joint, and an attempt to develop a new fixing method without the cement.

In the course of these efforts, it was found that a flumina ceramics having a low wear rate is suitable for use in the joint. The first attempt to use ceramics in place of metal at the head of the thighbone was made by a man named Boutin. Now ceramics are being used for repairing damaged thigh joints in various countries including Germany, Switzerland, France, and Australia, not to mention Japan. When using ceramics in the joints, there are two types of material combinations available: 1) a combination of the alumina socket and the alumina head of a thighbone; and 2) a combination of ultrahigh molecular weight polyethylene (UHMWPE) socket and alumina thighbone head. After 9 years of clinical applications of the ceramics, Boutin reported that the alumina-alumina combination was superior to a combination of the metal socket and metal bone head and another combination of the UHMWPE socket and metal bone head. But in using the alumina-alumina combination, the problems involved concern the collision and friction between two rigid bodies--i.e., the alumina socket and the alumina bone head.

On the other hand, many reports of clinical application results on the combination of UHMWPE socket and ceramic bone head have been made in various countries centering on Europe. It is expected that the combination could become the mainstay of the combinations of materials for use in artificial thigh joints in the future. Figure 1 illustrates an example of the imbedding of a UHMWPE composite material socket into the pelvis and a ceramic thighbone head into the bone, with both the socket and ceramic bone head developed by the authors of this article.

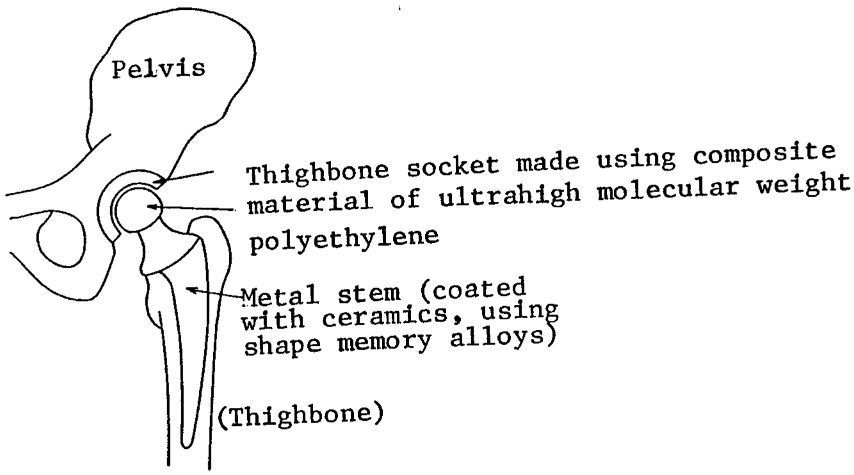


Figure 1. Example of Utilization of Ceramics Part and Composite Material in an Artificial Thighbone Joint

3. Artificial Muscles

The muscles of humans and other animals belong to a mechanochemical system in which chemical energy is converted directly into mechanical energy. The first advantage of creating a new type of actuator by applying the mechanochemical principles is the availability of a smaller actuator having higher efficiency, as the material to be used for building the actuator has the capability of energy conversion itself. In the mechanochemical system, the efficiency of an item having been created by applying the mechanochemical principles is not dictated by the dimensions of the item. The second advantage of using the mechanochemical principles is that an actuator to be created by applying the principles can use chemical energy which has a high energy density as an energy source. Conventional actuators currently in use require a bulky power supply or hydraulic unit outside the actuator unit. But in the mechanochemical actuator, it is possible to create a smaller actuator which contains the power house. The third advantage is that it is possible to create an actuator fit to any type of bone structure due to flexibilities in the materials used for the actuator. All these features of a mechanochemical actuator represent the principal requirements that must be met in creating artificial muscles.

Following are a number of macro molecule materials which have been found to reversibly contract or expand as a result of mechanochemical reactions occurring in them: 1) proton shift type; 2) ion exchange type; 3) chelate formation type; 4) oxidation-reduction reaction type; 5) phase transition type; 6) intramolecular rearrangement type; and 7) intramacromolecule mutual reaction type.

Figure 2 shows the structure of the proton shift-type polymeric material. In the (polyaniongel)-type structure in the figure, the protons in an alkaline solution exist in a dissociated condition, and as a result the network

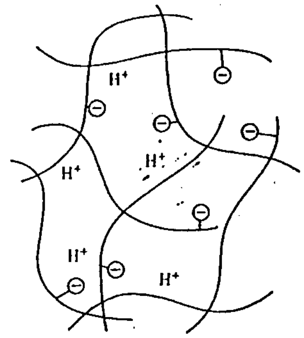
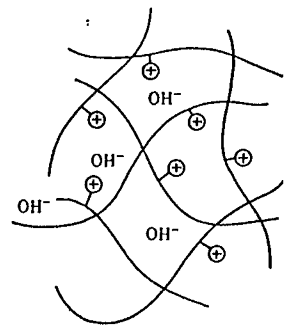
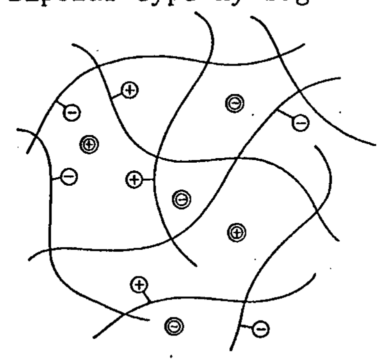
Unipolar type hydrogel (Polyaniongel)	Unipolar type hydrogel (Polycationgel)	Bipolar type hydrogel
		
H^+s dissociate at PH>4 and the network is charged negatively. This causes the elements composing the network to repel one another, causing the gel to swell. H^+s reunite at PH<4 and the gel contracts helped by its elasticity.	At PH<10, OH^-s dissociate and the network is charged positively. This causes the elements composing the network to repel one another, causing the gel to swell. At PH>10, OH^-s reunite and the gel contracts helped by the elasticity.	When PH is in the range of 4 to 10, high polymer electrolytes dissociate and the network carries both positive and negative charges. These charges pull one another with Coulomb forces and as a result the gel contracts. At PH<4 or PH> 10 the gel swells with only (polyanion) or (polycation) left.

Figure 2. Mechanochemical Polymeric Materials

remains negatively charged. This causes the elements composing the network to repel one another, and as a result the gel swells. On the other hand, in an acidic solution the protons return to their original reunited condition, and this causes the network to loose the charge, and this in turn makes the network contract automatically because of its elasticity.

The chief problem with the mechanochemical materials developed so far is their general slowness to respond. In terms of contraction power some of them have the ability of natural muscles, but they can take as long as several minutes to fully respond to a stimulation.

At our laboratory, we have been conducting research in an effort to improve the responsiveness and controllability of the mechanochemical system. To improve the responsiveness it is necessary to cut the time which the ions in a mechanochemical system solution take to disperse, and at the same time reduce the flow resistance within the gel when a swelling or a contraction occurs in the system. Our efforts for synthesizing a new mechanochemical material were focused on reducing time and resistance. As a result, we succeeded in synthesizing material which we call mechanochemical hydrogel composite. It has a high water content and high material strength. The

material has been produced using PVA as the principal ingredient and by introducing macro molecule electrolytic substances of a weak acidity and basicity. The materials we developed are divided into two categories--the unipolar type and the bipolar type. In the bipolar type material, we obtained the fastest-ever response time with the time constant of about 3 seconds in the 100 vm film. The technology which has been available so far for the development of a mechanochemical system enabled us to create a mechanochemical material whose generated strength was one-tenth that of the natural muscles, and whose responsiveness was one-hundredth that of the natural muscles.

In the development of artificial muscles, we must proceed with efforts geared toward the development of a method for controlling the conversion from chemical energy into mechanical energy through electrical stimulation of the material.

The muscles in the body of a living creature represent a functional body composed of a cluster of protein molecules that make a regular pattern in the cluster mode. The development of artificial muscles by modeling them after natural muscles calls for the unraveling of various basic questions concerning the principles involved in the working of the muscles, prior to proceeding with developmental work. Those questions include the unraveling of the mechanism responsible for generating muscular function, the development of technology needed for carrying out the measurements at the protein molecule level, and the development of the technology for manipulating the molecules in constructing artificial muscles. The research on mechanochemical science must be stepped up in the future to realize the application of mechanochemical technology to engineering, where any tangible benefits can be yielded relatively easily once we have achieved a goal in mechanochemical research. But at the same time, it is also important to maintain unflagging and unique research that may not be related to the engineering directly, in view of strengthening the foundations of mechanochemical science.

BIBLIOGRAPHY

1. Tateishi, T., OHYO BUTSURU [APPLIED PHYSICS], Vol 54 No 10, 1985, p 1052.

2. "Functional Macro Molecules," compiled by Kohbunshi Gakkai [Macro Molecule Society], and published by Kyoritsu Shuppan, 1974, p 573.

Vital Functions Chemistry, Applications

Tokyo KOGYO GIJUTSU in Japanese Jul 86 pp 7-9

[Article by Hideaki Tanaka, chief, Department of Natural Organic Chemistry at Kagaku Gijutsu Kenkyusho]

[Text] 1. Unraveling Vital Functions and Imitating Them

Things which have been developed by observing and imitating body functions and putting them into engineering applications are aircraft, cameras, catalysts, artificial leather, computers, and nylon. When seen from the engineering point of view, all these things show better performance than similar functions in the body of living creatures. It could be said that a purpose of engineering research is to imitate body functions of living creatures, and to develop things which, having been created by imitating, display better performance when seen from an engineering aspect. Prior to trying to imitate body functions and realize them through engineering applications, two problems must be resolved. One is the necessity to unravel the basic principles involved in the workings of a specific body function. The other concerns the creation of the materials to be utilized for the engineering realization of a specific body function. To develop an item which is convenient and comfortable for us to use and superior to the corresponding body function in terms of engineering capabilities, balanced progress in the research of these two problematical points must be made.

There are some vital functions, the working principles of which are not difficult to understand. But understanding the working principles of the others are not so easy, and this produces difficulties when trying to imitate vital functions. In fact, we are impressed with the sophistication with which vital functions operate. For example, modern day computers are in some respects far superior to the vital functions of a living creature. But it is a fact that there are some aspects in the sophisticated information processing function of living creatures, which even the most advanced models of the presently available computers have been unable to imitate. Under these circumstances, trying to unravel the mechanism of the working principles of such vital body functions in the atomic or molecular levels could produce some useful hints that could be used in our efforts to apply body functions to engineering applications.

For example, the artificial leather which was created using macro molecule materials and had been used until recently tended to develop cracks on the surface or had bad moisture permeability and this made it no match for natural leather. But the quality of the artificial leather we are using today has improved and now is far superior to its natural counterpart in respect to engineering functions. This has been made possible as a result of progress in unraveling the mysteries of good quality natural leather, and a progress in research for better processing techniques of macro molecule materials in recent years. The reason why a bird can fly can easily be explained. In mankind's long cherished aspiration to transform the principles involved in a bird's flight into a practically workable

engineering object, materials and the engines needed to construct a plane have been developed. However, as seen in the development of the aircraft, research aimed at realizing an artificial function similar to a vital function outside the body of a living creature using materials completely different from the substances composing the body can no longer be regarded as the chemistry of vital function. It may be self-evident that such research is solely for the development of aircraft and has nothing to do with body function-related research.

2. Exploration of Vital Functions and Methods for Artificially Combining Molecules

Today there are many kinds of industrially used catalysts which are superior to enzymes, including those used in the production of polystyrene and polyethylene. But the advantage of using enzymes is that they often make it possible for chemical reactions to proceed under normal temperature and pressure conditions, where high pressure and high temperature reaching more than 100°C and a strongly alkalic or acidic reaction environment are required when a similar reaction is made outside the body. The relationship between the enzymes and the substrate is likened to the keyhole and the key. The "keyhole" is formed by a cluster of giant organic molecules and is soft. The complex and irregular features inside the keyhole make the organic molecules fit snugly into the substrate molecules. The cluster of these molecules is constantly producing complex vibration repeating contractions and cluster swelling. The keyhole has the ability to concentrate the vibration energy to a specific point inside the cluster. Recently, it has become apparent that the soft and irregular features inside the keyhole play an important role in the molecular recognition function and in making it possible for chemical reactions to occur under a temperate reaction environment. To a certain degree, it is possible to cause a reaction similar to an enzyme reaction using the organometal complex catalyst of a low molecule or some other kind of catalyst. The high degree of molecular recognition function is peculiar to the giant molecules. The proteins forming enzymes are composed of more than 20 kinds of amino acids, with a few hundred of these amino acids chained together in accordance with the rules of order. Theoretically, it is believed possible to create a catalyst which is capable of causing a reaction by performing high level molecular recognition as enzymes do, that is if we could construct giant molecules by chaining a few hundred artificial molecules in an order similar to that of the amino acid. But at present, there are no practical methods in the field of organic chemistry for building such giant molecules.

3. Application of Protein Engineering to Usages Outside the Body of a Living Creature

By using a protein engineering method involving gene manipulation, it is possible to create giant organic molecules as designed. The advantage of protein engineering is that it enables one to actually create giant molecules as designed. At the present juncture, it is still impossible to forecast the functions of proteins even if the space configuration of proteins was completely known, which is not the case. But we believe it will

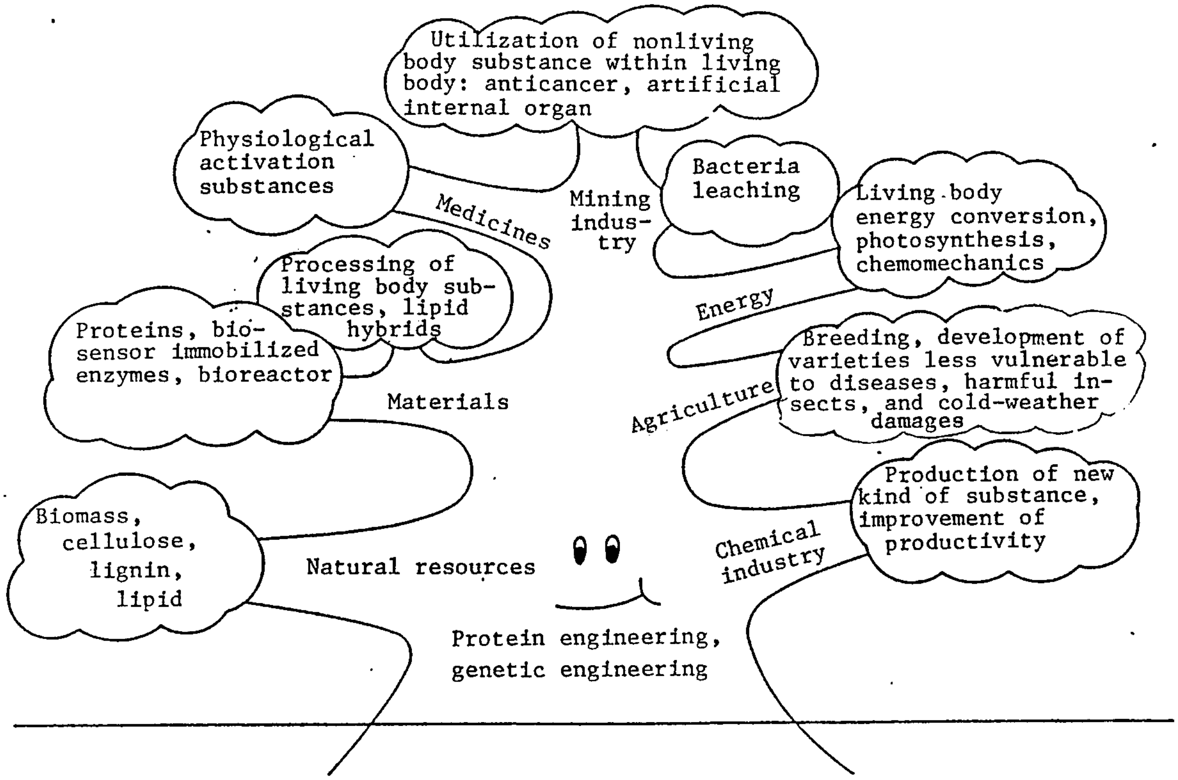


Figure 1. Tree of Vital Function Chemistry

certainly become possible to theoretically forecast functions in the future after we have accumulated more relevant data, because the relationship between functions and configurations of amino acids in proteins is of a univocal nature. When forecasting space configuration of proteins and their functions becomes possible from the configuration of the amino acid, the benefit will be incalculable. In general, proteins are regarded as an unstable substance. But among enzymes there are some which display good stability even under a temperature of 90°C. When we have unraveled the mechanism responsible for stability, we can also make other unstable enzymes more stable through protein engineering techniques. Making enzymes stable is the most important prerequisite when using proteins for the applications outside the body of living creatures. When stabilization is achieved, bioreactor and biosensor application fields will expand greatly. In addition, the development of biochips using proteins will also become possible. In the 21st century, there is a possibility that a new type of industry will spring up as a result of mounting interest by people in their health. Under these circumstances, there is a possibility that the biosensors integrating a few thousand protein hybrids on a chip with the hybrids stabilized using protein engineering techniques would be utilized, just like we do the silicon integrated circuit chips in today's electronics, for the management of health.

4. Design of a Vital Function

It is possible to simulate a body function of a living creature by artificially creating proteins which work inside the body of the creature. All the substances in the body of a living creature are being synthesized with

the help of the enzymes inside the body. Consequently, if we could unravel the relations between the body functions and the working mechanism of the enzymes at the atomic or molecular levels, it would become possible to design a body function which has the ability of synthesizing new substances. In the 21st century, it is expected that the demand for the development of new body functions by designing a new DNA structure will mount to unexpectedly great proportions. This will lead to the formation of a new industry. Among those body functions, the one which is drawing particular attention for its increased applicability to engineering applications is the function for creating the living cell membrane composed of lipids and proteins. The cell membrane plays important roles within the body including photosynthesis, energy conversion, molecular recognition, and controlling movements of the substances within the cell.

When the relevant research being conducted now makes further progress in the future, the range of the body functions of a living creature which can be limited artificially could also expand further. But this does not necessarily mean that in the distant future we would become able to artificially realize any functions of a living creature freely. However, considering the fact that unflagging research efforts by our predecessors has led to many findings of new enzymes and clever mechanisms in the bodies of living creatures, we should proceed with our current research by bearing in mind that our new findings will provide important hints and repercussions on the future of engineering research.

Practical Application Process

Tokyo KOGYO GIJUTSU in Japanese Jul 86 pp 9-11

[Article by Hidekatsu Maeda, chief, Enzyme Engineering Research Section, Microorganism Application Department, Biseibutsu Kogyo Gijutsu Kenkyusho]

[Text] A concrete example of the fruits of developmental research in the new field of vital function application by fusing them with engineering techniques can be seen in the development of enzyme sensors and enzyme stabilization catalysts. In the following section of this article I will describe the present situation and future outlook of the application of vital functions to the process producing a new product by merging functions with engineering techniques.

By experience, it was discovered that applying a certain vital function helps in the production of a useful product. The application of a function to the production of wine is a famous example of this. However, it was only about 125 years ago, after the famous experiment by French chemist, Louis Pasteur, that some living body functions, particularly the function derived from microorganisms (yeast), began to play an important role in the production process of wine by being used for production. It was about 60 years ago that an ethanol production process using yeast was incorporated into modern chemical industry processes for the production of useful materials. When the price of imported oil was hovering at \$28-\$32 per barrel, the production of ethanol from blackstrap molasses had a cost advantage over

the synthetic chemical process in which ethanol was made through hydrogenation of ethylene. But now with the price of imported oil having decreased to $10-$15 per barrel, the production method using blackstrap molasses no longer has the cost advantage it had enjoyed.

At present, about 80,000 tons of L-glutamic acid are being produced in Japan annually for use in the production of seasonings and for other purposes, and about 30,000 tons of lysine as an additive to animal feed and for other purposes. These kinds of amino acids and other kinds of amino acids are being manufactured by making use of some vital functions, mainly by using microorganisms. Amino acids with such chemical structure complexity can be synthesized chemically very easily. However, the problem in producing amino acids using a chemical process is the formation of (cerami) body containing both the D-body and the L-body. To obtain only the L-body an optical resolution process must follow. Whereas in the production of amino acids using bacteria, only the required L-body can be produced, making this method more efficient than the chemical synthesizing method. Due to this, in the production of amino acids, excluding methionine and glycine, a method incorporating living body functions is popularly being utilized.

When compared with the modern organic chemical synthesizing method, there are no novel reactions occurring in the production method incorporating vital functions. All types of reactions involved in the method can be replaced by similar organic synthesizing reactions. But, as I pointed out in the preceding passage on the production of amino acids, there are still many cases where using a method based on vital functions is more efficient in producing an item than using the synthetic reaction process. In light of this, I am of the opinion that replacing the synthetic reaction process with the living-thing reaction process must be studied earnestly in an effort to improve the efficiency of the production process. But this living-thing reaction process should not be considered the best method available. In this sense it is not appropriate to try to replace all aspects of the synthetic reaction process with living-thing reaction process. The task we must tackle in our research in the future is to develop a method which enables us to effectively apply the living-thing reaction process to organic synthetic chemistry.

When considering the future outlook in applying vital functions to industrial production processes, we must pay due attention to the following two points. The first point concerns the questions of asymmetric synthesis and stereoselective synthesis, an outstanding problem in the field of synthetic chemistry technology which has yet to be resolved. In pushing forth the relevant research, researchers must try to find how the production process based on vital functions could contribute to solving this question. Within the bodies of all kinds of living things, including plants and microorganisms, asymmetric synthesis and stereoregulatory synthesis occur constantly. These synthesis processes are producing various chemical substances, some of which are completely foreign to us. In this connection, there is a scientific domain called natural substance chemistry dealing with such chemical substances. The antibiotic produced by some kinds of microorganisms and narcotics produced by some plants are the instances of such substances. It is apparently inappropriate to directly apply the special functions these

microorganisms and plants have to the aforementioned question on asymmetric synthesis and stereoselective synthesis in an attempt to unravel the mechanisms involved in synthesis. On the other hand, active efforts are underway here for the development of asymmetric complex catalysts aiming at applying them to asymmetric synthesis and stereoselective synthesis. Under these circumstances, it is expected that in the future a new stereoregulatory synthesis technology will emerge as a result of the parallel use of vital functions and complex catalysts in industrial applications and as a result of competition arising between the two parallel technologies. As a result, this will prompt the synthesis of unfamiliar and strange organic compounds, and will exert a great impact on the development of new industrial materials and medical as well as agricultural chemical products. At present, it is possible to synthesize a compound by optically splitting the materials. The number of asymmetric carbon atoms remains at three or so, but when the number increases further to five or more, it becomes no longer possible to synthesize a compound using the optical method. The introduction of a biological process is expected to offer a means of overcoming such a difficulty.

The second point concerns the conservation of energy. Regarding the outlook of the international demand-supply situation of energy in the 21st century, this author believes that it will not be much different from the present, though the price may be a little higher. But what bothers this author is the possibility of further deterioration and pollution of natural environments, namely the increase in CO_2 density in the air, the destruction of forests on a global scale, and the aggravation of air pollution by SO_2. Pollution by SO_2 has already reached a grave situation with acid rain falling in many parts of the world including the United States and Europe. Under these circumstances, will industries be allowed to continue using conventional production processes which consume a lot of energy? The production of ethanol using yeast is a good example of an energy conservation production method. At present, research is underway for the production of acrylic amide from acrylonitrile; a fatty acid from a tryglyceride using lipase as an enzyme; and monoglyceride, a substance well known as a surface active agent for use in food production, from tryglyceride. The processes for the production of these substances, when put into commercial operation in the near future, would contribute significantly to the conservation of energy. In judging the advantages of each of these production processes by comparing the energy consumption level, the total consumption level must be calculated by also taking into account the energy consumed at the "downstream processing" stages. For example, when producing something with the aid of vital functions of a living being, the amount of energy consumed for the production is not so high. But when the density of the product in the final stage of the production process is less than 1 percent of the fluid containing the product, the cost required for the separation of the product and the treatment of the fluid as industrial waste could reach enormous proportions. The production process which makes use of vital functions employs water as a solvent. The water, which has a large latent heat for evaporation, makes the production method disadvantageous compared to the organic synthesis method using an organic solvent, in extracting the product created.

By taking into account those questions thus far described, the major task we must tackle now is the effort to search for a new useful enzyme, the development of a stabilizer for a more active new enzyme catalyst. To be more specific, the effort to find a new useful enzyme will involve trying to find a new enzyme having novel vital functions, by screening those microorganisms which have the potential ability to produce so-far-not-known substances or have a completely new catalytic capability with them. An attempt to create a new type of enzyme is being made using protein engineering techniques. However, it is believed that we might have to wait another 100 years before we succeed in developing the new enzyme, which could be applicable to the production of useful materials by promoting the living-thing reaction. For some years to come, the task of biochemistry researchers will be confined mainly to the effort to find microorganisms having the above-mentioned capabilities by screening microorganisms living in natural environments.

When combined, the total volume of microorganisms on earth could reach an enormous level. These tiny creatures are constantly experiencing natural mutations stimulated by the ultraviolet rays of the sun, and as a result new types of microorganisms are being born. There is a famous industry story about nylon. According to the story, nylon decomposing bacteria came into being about 20 years after nylon was developed, and about the same number of years after the appearance of the bacteria a nylon decomposing enzyme was successfully created. Prior to launching the screening, we were required to develop a new screening method to enhance the hit rate of a new useful microorganism. The same applies to our efforts to screen those known kinds of enzymes in a bid to dig out an enzyme having the highest stability. The introduction of robots would be one way to increase the efficiency of the screening. These efforts would lead to further progress in enzyme-related R&D in the future.

Anticipated Benefits From Vital Functions

Tokyo KOGYO GIJUTSU in Japanese Jul 86 pp 11-13

[Article by Keishiro Tsuda, chief, No 1 Department, Sen'i Kobunshi Zairyo Kenkyusho]

[Text] 1. What Is "Being Alive?"

The question this subtitle poses is the starting point when we discuss the question of applying vital functions of a living being to engineering. Recently, research on this engineering has entered into a new phase of development. To promote engineering research, first there must be the need in the industry for the introduction of engineering technology, and second, it is necessary to establish good technological foundations which would help promote the research. Regarding the need, researchers in some fields of engineering are trying to get hints from vital functions, which they intend to use to break a deadlock in their research. As to the technological foundation, spectacular progress has been achieved in the recent past in the fields of electronics and the development of new materials. In addition, a revolutionary achievement has been made in the biological field, centering on DNA manipulation technology.

Regarding the history of biological engineering, research on bionics was started around 1960, followed by research on biomimetics chemistry around 1972. Research on "new" biotechnology centering on DNA manipulation was launched in 1973. Today, the fruits of biotechnology research are being introduced into various fields of industry, including medicine, agriculture, and engineering.

Research on biological engineering can be divided into two fields: a field aimed at achieving harmony with living beings through medical means, and a field aimed at applying vital functions to ecology through engineering means. Vital functions are being used through one of the following three ways: by using the body of a living being, by simulating the functions, and by combining the simulated functions with the body of a living being. In the following, my discussion will be focused on the simulated use of the functions.

The simulation of a specific vital function is aimed at artificially realizing a similar function suitable for a specific application need. To successfully simulate a vital function, a number of problems have yet to be solved. At present, efforts are being made to introduce vital functions as a means of achieving breakthroughs in the deadlocked research for the production of artificial enzymes, for photosynthesis in energy-related fields, and for the development of new information processing technology by imitating functions of the brain. Each of these research items is aimed at developing a superior catalytic function, a new light energy conversion function, and a new information processing function. What has been described above concerns the software aspect of the simulation; the hardware aspect concerns the building of the structure needed for the realization of the simulation.

The structures which could be employed for the simulation of a desired artificial function are quite varied. For example in the case of functional proteins, the synthesis processes involved range from one for synthesizing a natural protein to one for synthesizing a protein with its quality partly modified, to one for creating a protein having a completely new function. There is a case of simulation using other kinds of substances which have the same function; in this case, the mechanism for generating the function is nearly the same in principle, but there is a difference in the kinds of the substances involved. In other variations of the simulation mode, there is a case in which the function involved is the same, but there are differences both in the substances involved and the mechanisms for producing the function. It can be said that the former type of simulation (in which the substance involved is the only different element) belongs to the so-called hard-type simulation, and the latter type to the soft-type simulation. Generally speaking, the higher and more complex the function to be realized, the more practical it would be to try to produce the function through the soft-type model simulation, rather than through the hard-type model, a model which is closer to the mechanism of the vital function being simulated. For example, the method for simulating the functions of the brain belongs to the soft-type.

Prior to launching the development of the vital function simulation, it is necessary to unravel the function mechanism, irrespective of the types to be adopted for the simulation system to be developed. Now we are witnessing a stepped-up effort to make use of vital functions in various industrial applications in the country. Under these circumstances, it has become more important for we researchers to find the answer to the question, "What is 'living?'"

2. Methods for Synthesizing and Structuring Materials Derived From a Living Body

In the following section, I will describe the methods for synthesizing and structuring materials similar to those found in the body of a living being, as an example of the hardware mode simulation of a vital function.

First, I will take up the synthesis of molecules. Regarding proteins, the tertiary structure (stereo structure) is defined by the primary structure (amino acid configuration). By taking an enzyme as an example, the chained molecules form the stereo structure and define the active portion and the spatial configuration of the functional groupworking within the protein. At present the spatial configuration of synthesized giant molecules is allotted statistical distribution patterns which cannot be decided easily. But considering that the synthesis of sequential giant molecules aims at realizing a designed function by controlling the configuration of the monomer units involved, the same function should be realized using the same stereo structure. In this connection, the aim here is to attempt to define the stereo structure by the primary structure. There may be many more years before this is realized successfully. But in this sense, protein research is regarded as the ultimate research model for functional synthesized giant molecules.

The stereo structure of proteins is supposed to be defined by the primary structure. But in reality it is difficult to forecast a higher order structure from a primary structure. However, relatively good results (50 to 70 percent) have been obtained in forecasting the secondary structure (helix structure, etc.). In the United States, an attempt is being made to make a protein model aimed at defining the stereo structure, by designing and synthesizing the structures with high structural predictability rates, including the helix structure. Such a protein could also serve as the basic structure of the enzymes to be synthesized artificially. Even in Japan, research is underway to synthesize an electron transmission system (bioelement) by putting the functional group to the side chain of the amino acid forming the helix structure (September 1984 issue of GENDAI KAGAKU). In this sense, research for spatial arrangement of the functional group by defining the stereo structure with the primary structure is already underway in this country.

In the case of proteins, the tertiary structure as the subunit structure forms the quaternary structure. For example, hemoglobin forms the molecules having the quaternary structure from two α chains and the same number of β chains. Incidentally, molecules having subunit structures exhibit more complex reactions than molecules not having the structures. A ribosome is

another substance similar to hemoglobin. (In actuality, however, a protein is synthesized from ribosome RNA and the aggregate of many smaller subunits in accordance with the instructions of mRNA.)

These are solid aggregates. (In actuality, they are thermally fluctuating.) The vital film over the aggregate has a basic structure in which functional proteins are floating on a lipid double film, and the proteins can move inside the film. Ionophore has the function of transporting specific ions inside the film and has a high function level as the aggregate. It is so to speak a soft structure. Those functional proteins when gathered together form a system and interact among themselves. The aggregate enzyme systems which are known by the names so-and-so circuits are examples of the aforementioned system. In these aggregate systems their functions become increasingly sophisticated as their order advances. When the molecules in the system have been replaced with cells, the system could become a nervous system, for example, which then forms part of a high-level sensing organ.

The self-aggregation characteristic of the vital elements plays a major role in the formation of the aggregates described so far. The self-aggregation characteristic has been applied to the formation of ribosomes and monomolecular films. As a result, success has been seen in restructuring ribosomes and mitochondria. But at present relevant research has not advanced to the degree where the restructuring method can be used in practical applications. When this becomes possible, we would be able to create molecules by placing the functional group at any desired spatial location, and in addition, to synthesize compound molecules by combining these molecules as a subunit. In the future, a new functional element formation method would be developed.

3. Future Development

The research of vital function application to engineering has made significant progress in the macroscopic domain in recent years. With this development, the necessity for research emphasizing the microscopic aspects, namely research focusing on molecular aspects, has been mounting recently. In the development of new useful materials, this means that more detailed design requirements would be imposed in the future. In the following, I will refer to expected future developments in some fields of research, including one for the application of vital functions to engineering. First, concerning the material development, it is expected that progress in the synthesis of artificial enzymes will be accelerated being influenced by continued progress in protein engineering. In energy-related fields, research on photosynthesis technology will make further progress. In the mechanochemical field, increased research is underway in an effort to apply the revolving mechanism of the bacteria's flagellum motor to engineering. The body of a human being is equipped with superb information-related systems. Besides the nervous system, it has various kinds of information handling systems. For example, protein synthesis is a body information system. The significance of progress in DNA manipulation techniques is that it has made it possible to exploit the protein synthesis system. As a result of the ongoing increased research, more progress will be forthcoming in efforts to introduce the superb mechanism of information-related systems in the human body in the future.

So far in this article, I have discussed the prospects of future developments in our research for exploiting useful vital functions. There might have been some aspects in what I have described in this article, which sound a bit too optimistic at present. I conclude this article by asking the readers' patience on this.

Vital Functions, Engineering Relationships

Tokyo KOGYO GIJUTSU in Japanese Jul 86 pp 13-14

[Article by Shigeru Yamane, senior researcher at Pattern Information Section of Denshi Gijutsu Sogo Kenkyusho]

[Text] The attempt to apply vital functions to engineering is not new. In fact, bionics was born a quarter century ago in 1960. As a precursor to this, an American named Wiener dealt with the science of communications and control of animals and machine in his 1948 book entitled "Cybernetics." During the years since the birth of bionics, was any progress made in the application of vital functions to engineering? The answer is "yes" in only a handful of the engineering fields, but the answer is "no" for most other fields. The field where we can say "yes" with confidence is the field of genetic engineering with active research being conducted in many countries. Research includes human gene manipulation to produce useful substances, and the breeding of plants and domestic animals. In all these cases, vital functions involved in the applications are made to work at high efficiencies within the bodies of living beings to which they belong. This means it is not necessary for researchers to thoroughly understand the structures of the genes involved as well as the structures and the synthesis process of a useful substance, as long as the substance is being produced efficiently. This may be the reason why research on genetic engineering has made such spectacular progress recently.

But the situation is different when creating an engineering device or a machine by introducing vital functions themselves or their structures into it. Difficulties are experienced in applying the vital functions to the machine by further refining the functions through engineering means. The main reason for this difficulty is that it is not an easy task to unravel the working mechanism of vital functions, and in addition difficulty tends to increase as functions become more sophisticated. Let us consider the human brain. It is generally admitted that the human brain has the most sophisticated functions. There have been many scientists who dreamed about creating a machine which realized some of the functions of the brain. During the past 20 years significant progress has been made in biological research involving brain functions and in the field of science dealing with the nerves. In pushing ahead research, two distinct tendencies have been observed. One is a tendency to emphasize research involving microscopic matters, such as molecular structures of cells. The other is a tendency to focus on macroscopic research, such as efforts to find a new function for the nerve cells in the brain. Certainly some progress has been achieved in unraveling molecular structure through microscopic research, and to a lesser degree relations between the structure and the brain functions

at the cell levels. But there have been none who succeeded in realizing the functions of the brain in the devices they produced by applying the fruits of microscopic research. In macroscopic research, too, progress has been made in developing a number of useful cell functions, though realization in engineering application has proved difficult. In addition, researchers have yet to unravel the mechanism of the nerve circuit. In the field of macroscopic research, a number of nerve models have been proposed so far to realize the useful functions of the nervous system through engineering. But when seen from an engineering point of view, the development of such a vital function using the proposed models has a very slim chance of success. In fact, those models tended to be rudimentary in general in their concepts, that could have been conceived easily even without seeking hints from living beings. Considering these facts, the area of research which is expected to play a vital role in furthering the engineering application of vital functions is one which has not been covered by the above-mentioned biology and nerve science.

When one thinks of these facts mentioned thus far, one will get an impression that the attempt to introduce useful vital functions into engineering applications has little prospect of success. But despite this bleak prospect, we must continue our research due to the following two reasons: 1) The research is necessary in order to promote artificial intelligence. At present, active research is underway for the development of artificial intelligence aimed at developing "thinking" computers. In fact, significant progress has been made in the research so far. But in the course of the research we found that there could be a big gap between the superb functions of the human brain and the ability of artificial intelligence when it has been developed using the scheme conceived thus far. The sophisticated functions of the human brain being considered here concern thinking, conjecture, language, learning, recognition, and memorization. To narrow the gap, it is necessary to devise a completely novel scheme. Even in the field of artificial intelligence, we are experiencing a deadlock at present. In an effort to break this stalemate, the possible route we are going to take is to resort to imitating the mechanism of the human brain. 2) Stepped-up research is needed considering the fact that some scientific knowledge and findings which serve as the base of today's high technology were founded more than 100 years ago. To cite some application examples of vital functions to engineering from among those which we are using in our daily lives, televisions and audio equipment are being produced by applying the visual and acoustic characteristics of human beings. Most of the knowledge and findings were not a result of research specifically aimed at such findings, so that they could be applied to engineering utilization, but in the course of ordinary scientific research. The fruits of the research have been introduced into engineering fields whenever the introduction of scientific knowledge and findings was deemed useful. In reality, however, only a small portion of the knowledge and findings are being used in engineering applications today. Despite this, engineering has been benefiting unilaterally from progress in scientific research on the vital functions without reciprocating the benefits it has been enjoying.

Despite this, stepped-up research must be made in scientific fields to further accumulate new knowledge and findings to keep serving the advancement of engineering.

When seen from these two viewpoints which have been discussed thus far, the ongoing research of vital functions can be regarded as an intelligence science aimed at accumulating new scientific knowledge and findings. The nature of such research is naturally different from research aimed at developing something. In development research, the technological "seeds" needed for attaining the goal have ordinarily been readied by the time the development effort begins. This makes it possible for researchers to draw a blueprint of how to combine these "seeds" to attain their goal. Even when multiple ways of combining "seeds" are possible, researchers can draw up the best research plan through evaluation of each of the possible combinations based, for example, on efficiency, prior to formulating the final plan. In other words, when the plan concerns the development of a machine, for example, researchers can decide to a certain degree the internal structure of the machine prior to starting a full-scale effort for its development. This helps draw up the development research plan more efficiently. On the other hand, the goal of vital function-related research, especially research on the mechanism of the working functions, generally concerns unraveling of the internal structure of the things which are responsible for the functions. Consequently, in vital function-related research it is impossible to evaluate the courses of research to be taken, to explore the internal structure (truth) of a living body in a bid to find the most suitable course prior to launching research based on already available relevant information. Under these circumstances, the best possible way to proceed with the research is to have researchers in various fields having varied ideas proceed with their independent research, but in a parallel research theme (in competition with one another). This will lead to multiple new scientific findings by those researchers, and it is likely that there may be some among the findings which will prove useful for engineering application.

However, the major bottleneck impeding the application of useful vital functions to engineering is the slow progress in unraveling the working mechanisms of vital functions, as I have described in the preceding passages of this article. To solve this problem it is important to seek assistance from the engineering side, namely in the form of measurement and analysis technology. When trying to build a vital function model outside the human body based on the available knowledge and findings concerning the function, there may be some cases where the help of mathematics and information theory would become necessary. As described above, in the future it is expected that the fruits of research will be shared increasingly between engineering and intelligence science dealing with vital functions.

In efforts to accumulate new useful knowledge and findings in the field of intelligence science, the state-run research institutions are required to play a central role. When more useful scientific knowledge and findings become freely available in the future not only in Japan but also from foreign countries, then it will be industry's turn to take the leading role in developing vital function-based machines which are practical and convenient to use in our daily lives.

Mechanism for Controlling Body Reactions

Tokyo KOGYO GIJUTSU in Japanese Jul 86 pp 15-16

[Article by Neiichi Nagamura, chief, Physiological Information Engineering Section, Basic Human Engineering Department, Seihin Kagaku Kenkyusho]

[Text] For a certain period in the recent past, this author has been involved in the measurement and observation of various emotion-related phenomena in the human body, such as the expression of displeasure, in connection with the evaluation of the effects on humans of noise, low frequency air vibrations, and other kinds of displeasure-inducing environmental phenomena. When one is in a rage or feeling mental displeasure or has been driven into other forms of excessive mental excitement, various changes occur in the body. Those changes include facial flushing or paling, sudden difficulty in breathing, panting, sudden increase in heartbeat, dilation of the pupils, sweating of the palms, dryness of the mouth, and appearance of goose flesh.

These bodily reactions are called either an emergency reaction because some of them appear when one is faced with an emergency situation, or a defensive reaction because they are related with the attempt to take some action to protect the body from danger. Other body reactions in which the adrenocortical hormones play the major role and which have close relations with the above two types of reactions are known as (Cellia's) panadjustment syndrome or as stress reaction.

The above-mentioned research work in which this author has been involved is aimed at knowing how much noise and other related environmental nuisances are harmful to the human body, by continuously recording such body reactions using a polygraph machine.

When one investigates these reactions in the human body, one is always impressed by the wonders of nature involved in such reaction phenomena. Here let us consider an emergency reaction by supposing a situation in which one suddenly hears a snarl of a savage beast which is roaming one's vicinity. Upon hearing such a snarl, a body reaction occurs to prepare one for either running away from the scene hurriedly or attacking the beast. When the emergency reaction has occurred, the heartbeat rate increases to supply enough blood to the muscles of the body. At the same time, the supply of blood to the skin is restrained, and in the face this causes the skin color to turn ashen. This helps the blood loss to lessen when one is injured, compared with when the normal amount of blood is being supplied to the skin. When one is actually injured, the shock causes the peripheral blood vessels to shrink greatly and suddenly, and this limits the loss of blood to a minimum. In addition, breathing increases to help supply more oxygen to the body. Panting in such an emergency situation promotes the evaporation of moisture in the respiratory tract, and this in turn helps keep the body temperature from rising unusually high due to the heat generated by the brisk muscle movements all over the body. The sweating of the palms and of the bottom of the feet prevents one from slipping [as published]. The appearance of goose flesh causes the body hairs to stand upright, and this

makes the body appear larger, menacing the adversary. But in humans, the body hairs have now substantially atrophied, and the appearance of goose flesh now serves the intended purpose little. The dilation of the pupils is part of a series of reactions in the sensory system of the human body, which makes it easier to assess what is happening. Part of the information perceived by the sensory systems is transmitted to the section of the mid-brain known as the reticular formation to enhance the activities of the section. This leads to the reticular formation sending particular signals to the brain, enhancing in turn the activities of the brain proper. This then increases the sensitivities of the sensory systems to make them ready to receive external stimulation. Supposing a certain unknown object crossed the corner of one's visual field when the sensory systems are strained, a prompt body reaction ensues, causing one's face to turn toward the direction of the object. At this moment, the next action taking place in the thalamic section of the diencephalon causes the functions of those sensory systems other than the visual organ to be shut down, allowing the brain proper to concentrate on processing the information being perceived by the visual organ. These processes represent one's focusing attention to a development occuring in front of one. The thalamic section of the diencephalon is where the so-called relay stations of the sensory system networks converge, and the section is responsible for controlling the sensory systems.

Those emergency reactions described above are not the only body reactions being controlled. The automatic nervous system does a wonderful job of coordinating the various conditions inside the body of a living creature against, for example, the temperature changes in its living environment. When it is hot, the blood vessels near the skin surface dilate to promote transportation of the heat generated inside the body to the surface of the body so that the heat can be radiated from the skin's surface. Sweating helps promote heat radiation. Sweating involves a body reflex so-called half-side sweating, a phenomenon in which sweating is affected by whether external pressure is being applied to the skin surface or not. For example, when one sleeps by lying on one's side, sweating on the bottom side is restrained whereas sweating on the top side is promoted. This phenomenon is one of the abilities the body has to get rid of the heat inside the body effectively when such a need arises. When one sweats profusely, the density of the blood increases, and this in turn causes the heat capacity of the blood to increase, enhancing the heat transport capability of the blood. Among those animals who do not sweat, there are those who have a special blood vessel system known as the carotid artery network. In this special blood vessel network, the temperature of the blood flowing through the carotid arteries is prevented from rising abnormally high by the lower temperature of the venous blood flowing in the vicinities. The blood in the veins in such animals is cooled when it flows through those veins running along the windpipe. A rise in the temperature of artery blood beyond the normal level is injurious to the brain which is particularly vulnerable to heat.

On the other hand, when it becomes cold the blood circulation near the skin surface becomes restrained, and the skin loses moisture and wrinkles appear. In addition, smoothness on the skin surface is lost due to the appearance of goose flesh as a result of the muscular reaction responsible for causing the

goose flesh. As a result of a change in the skin surface condition, the air currents near the surface become stagnant and this leads to a lower radiation of body heat. A contraction of the goose flesh-causing muscles generates heat which helps keep the temperature inside the body at the proper level. When the cold intensifies, the body begins to tremble and this helps promote the generation of heat inside the body. A whale in the Antarctic Ocean is said to be equipped with a sort of heat exchanger at its tail to prevent body heat from escaping into the cold seas from its tail. In the heat exchanger, the cooled blood stream in the tail section heading for the center of the creature's body is warmed by the warmer artery blood stream from the body center, reducing the level of the heat lost into the seas.

As described thus far, our body temperature is maintained at a proper level through the functioning of those ingenious temperature controlling mechanisms. For proper functioning of those mechanisms temperature sensors on the body surface as well as the sensors deep in the body play an important role. The mechanism controlling the body temperature exists in a portion known as the hypothalamus which, located at the base of the brain, plays a vital role in controlling life-related functions. It is possible to artificially induce a series of reactions related to body temperature controlling functions by either heating or cooling the portion in question directly. In such an experiment, heating takes place by applying an electric current to the portion through a specially-made electrode piercing the skull, while the cooling can be done by introducing cooled water through a thin-diameter pipe. Both the skin and brain are responsible for controlling body temperature But, it is said that for body reactions which are to be induced against heat, the hypothalamus in the brain is mostly responsible, while against cold the temperature sensory and the controlling mechanisms on the skin are chiefly responsible. In other words, the brain which is vulnerable to high temperature takes charge of controlling body heat. In the hypothalamus there is also the sensory center controlling eating habits. There, the so-called hunger sensory center and full-stomach center are functioning in a competing fashion. For example, an animal which has fed to satiety suddenly resumes eating after the animal's hunger sensory center was stimulated with electric pulses and continues eating as long as the electric stimulation is applied. When the stimulation is interrupted, the creature abruptly stops eating. Under natural conditions, the stimulants of the hunger sensory center include insulin, glucose, and free fatty acids. The presence of these substances are detected by thenerve cells which act as a chemical sensor. Regarding the metabolism of water, it has been ascertained that there is a nerve which is sensitive to the osmotic pressure in the hypothalamus. It is also known that osmotic pressure-sensitive neurons in that part of the brain control body fluids by excreting an antidiuretic hormone. When the osmotic pressure mounts excessively despite the controlling by the antidiuretic hormone, the thirst for water is induced. In addition, the osmotic pressure-sensitive cells are present also in the hepatic portal veins and the duodenum, and all of them are responsible for controlling salt levels in the body fluids. Body fluids are also monitored constantly by the sensory organs located around the heart and the kidneys. When the fluids decrease below the appropriate level, thirst is induced through the activation of the hormone-based controlling mechanism.

The ingenuity of this life-supporting mechanism in the body of living beings is really marvelous. It can safely be said that the principal aim of research for controlling vital functions is unraveling this mechanism. But the complexity of the phenomena involved in the life-supporting mechanism makes research in that field the least productive among the research on brain physiology. However, the possibility that progress in the research would produce new knowledge and findings which would be useful for application to engineering makes the research worth undertaking despite the difficulties. The research concerns exploration into complex environments associated with the life-supporting mechanism, the controlling of the environments, the controlling of the complexity and the so-called predictable controlling. Until recently, research on the autonomous nerve system had been shunned by many scholars specializing in nerve physiology with research on the nerve system contemptuously dubbed as "a quagmire." But recently, slow progress has begun to be made also in this field. In this sense, research has a promising future.

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FRG-JAPAN BIOTECHNOLOGY INFORMATION PROJECT BIJANCA

Braunschweig BIOTECHNOLOGIE in German No 3, Mar 1987 pp 5-7

[Article by Dr. Rolf Schmid: "Biotechnology in Japan--National and Corporate Activities"]

[Text]1. A Science Contract Between the FRG and Japan

A "Contract Concerning Collaboration in Science and Technology" between the Federal Republic of Germany and Japan has been in existence since October 1974. It also comprises the exchange of information in biotechnology and medicine. There have been six relevant technical meetings, with participation by about 180 German and Japanese scientists. Primarily research results from both countries in the areas of

- enzyme technology
- gene technology
- cell cultures
- bioprocess engineering
- biological waste disposal

were presented.

2. The Acquisition of Information in the Federal Republic and Japan

A glance at the statistical data of both countries exhibits similarities. Thus, both countries are poor in raw materials, but due to their highly developed science and technology, they are major economic powers. Export surpluses are achieved on the basis of importing basic technologies.

Information concerning worldwide market and technology developments thus belong among the vital "raw materials."

The lively need for information on the part of the Japanese expresses itself in the daily editions of the six largest trans-regional dailies with 40 million copies. Not one "picture" paper, but papers of high caliber. With 1.27 copies per household, Japan has the highest reader density in the world. The largest daily and business papers can be consulted on-line for some years. More than 2200 monthly journals with a total of more than 1.8 billion copies (1980)

provide information on the natural sciences, engineering, and the intellectual life.

"In Japan, there is a striving for information."

"In Japan, one can be well-informed."

This is the conclusion of Dr. Rottenberg, the manager of the Tokyo office of the "Society for Information and Documentation", GID.

The Japanese Foreign Trade Ministry MITI clearly invests more heavily in information about the Federal Republic than is the case inversely. The balance is shifted further against us through the voluntary collaboration of the Japanese trading companies. With more than 200 branches and 3000 employees, just in Europe alone, they control worldwide 44 percent of the Japanese exports and 72 percent of the imports (1985).

One difficulty in acquiring information consists in the splintering of modern technology into complicated individual specialties. Thus, the technology committee of the German Embassy in Tokyo has only two staff workers, but they are expected to provide professional trend reports equally about Japanese automobile-, space-, electronics-, and robotics-industry, as well as reports concerning new materials, bioengineering, or gene technology.

On the Japanese side, this problem is solved by forming larger corporate associations. With consultation from responsible employees and with financial support, they sustain their own offices for the acquisition and propagation of information. BIDEC--the "Biotechnology Development Corporation", founded under the management of the MITI (Foreign Trade Ministry) is supported by 175 member firms; the monthly BIDEC newsletter contains everything worth knowing about internal Japanese developments. In addition, it also contains about 100 summaries, translated into Japanese, of Western scientific services and market analyses.

The German information gap is evaluated very differently by different parties. Industry feels "well-informed"--but with some exceptions, one must doubt this evaluation. In the long term there exists a need for information on the part of the BMFT (Federal Ministry for Research and Technology)--especially in view of supporting the international competitiveness of medium and small businesses.

3. Project "BIJANCA"

At the end of 1981, these considerations gave rise to a charge to the BMFT to work out the concept of a data base on "biotechnology in Japan".

Objectives and antecedent conditions

The need for information: What institutions/persons are pursuing biotechnology in Japan? What are the trends? Who is cooperating with whom?

Antecedent conditions: Project management in an honorary capacity, project staff members are part-time, data bases on a PC.

After five years of work, this project could be concluded successfully.

The results are the following:

o A data base with information concerning about 2,500 research sites and about 37,000 Japanese scientists in the area of life sciences (BIJANCA).

o A computer-supported system for the continuous updating of this information (abstract analyzer).

o Publication of this information in the form of a "biotechnology map" of Japan.

o Computer supported evaluation of Japanese biotechnology meetings (JASMEEN).

o Computer supported lexicon of biotechnological technical words in German-Japanese-English, 1986, published commercially (DIJANA).

o Numerous technical publications in German, English, and French.

The system is currently being installed at the Society for Biotechnological Research mbH (GBF) in Braunschweig. Beginning at the end of 1987, it will be available to the public for inquiries. Further project results from past years:

o Annual reports on "Biotechnology in Japan" in English and French for the technical world.

o Printing a biotechnology lexicon with about 6,000 technical terms in German-Japanese-English.

o Preparation of a manual in English concerning "biotechnology in Japan".

4. Biotechnology in Japan--A Survey

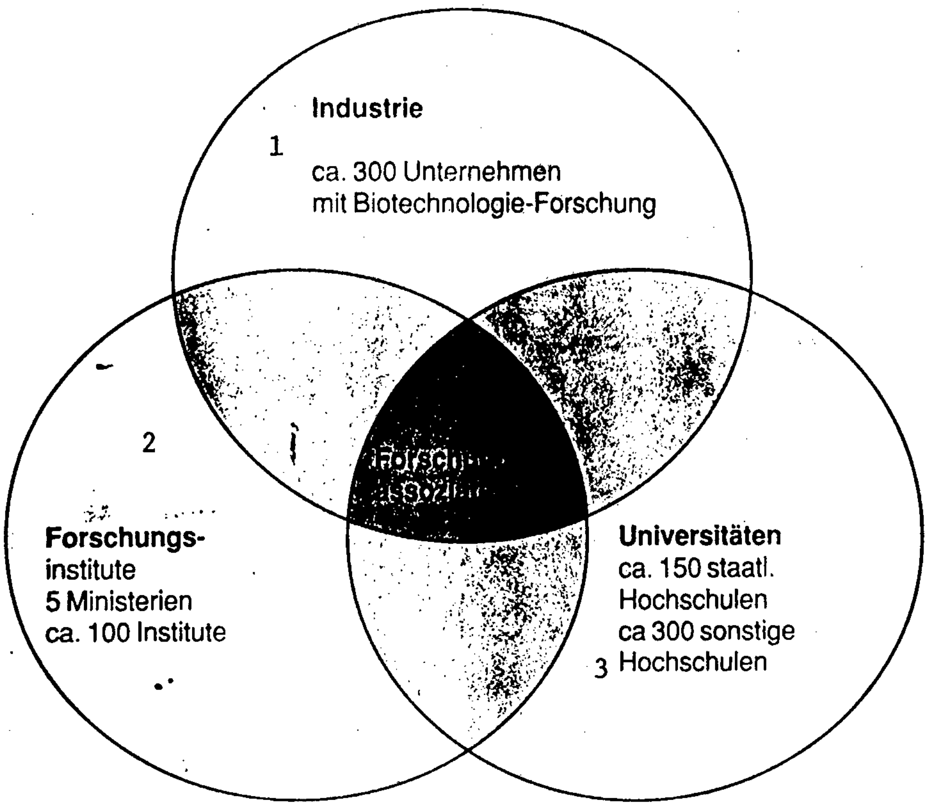
At this time, Japan is earning about 4 percent of its GNP with fermentation techniques. According to an estimate by BIDEC, this will amount to 10 percent by the year 2000 (15 trillion yen, about 200 billion DM).

As has already been successfully tried in other industrial branches (ship and automobile construction, computer technology, new technologies are opened up with a division of labor:

o A ministry furnishes an information base and funding means

o Industrial enterprises form research associations and, where possible, acquire foreign licenses for basic technologies.

Japan's Biotechnology-Research Potential



1 Industry about 300 businesses with biotechnology research
2 Research Institutes five ministries, about 100 institutes
3 Universities about 150 state colleges, about 300 other colleges
4 Research Associations

o Major research institutions and universities work out methodological foundations and examine working risks.

o The Ministry works out approval guidelines and protects the achievement internationally.

o The government encourages the regionalization of production sites.

The onset of a new "industrial generation" is therefore reflected in a concerted increase of personnel and budget. Thus, since 1981, the number of researchers and budgets in the life sciences in corporations, major research facilities, and institutes rose about equally by 50 percent, and in gene technology by 150 percent. In contrast to us, several ministries participate intensively in the development of new industries and actually compete with one another in a certain sense.

Japan--Expenditures and Personnel Deployment in the Life Sciences

	Total	Industry	Institutes	Universities
Research Expenditures (1984, billion yen)	784.1 154 %	370.9 145 %	98.5 175 %	314.7 158%
Expenditures for gene technology (1984, billion yen)	24.7 262 %	13.7 236 %	4.5 375 %	6.5 271%
Research Personnel (1985, persons)	108,802 147 %	27,811 121 %	12,235 156 %	68,756 157 %

Numbers in parentheses: increase compared to 1981 (costs) or with respect to 1982 (personnel).
100 yen = about 1.3 DM
Research personnel: In industry and in institutes, about 50 percent are scientists, at the universities, about 70 percent.

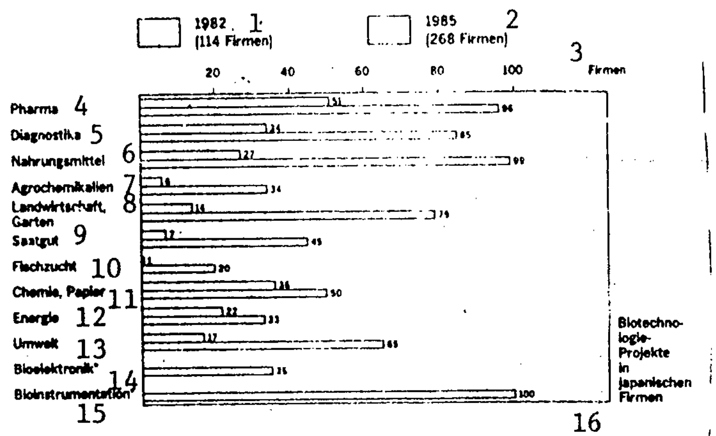
4.1 Industry

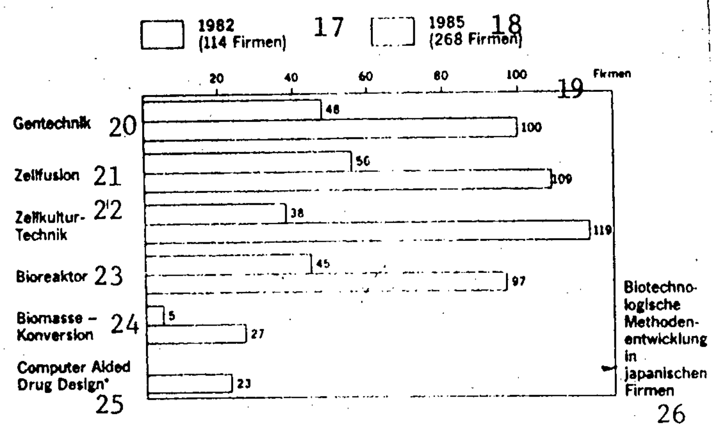
Fermentation firms like Ajinomoto and Kyowa Hakko, which are steeped in tradition, have for decades been supplying nearly 50 percent of the world market in individual segments, e.g. with the production of amino acids. About 200 large and medium enterprises in pharmacology, chemistry, and the foodstuff industry have for some years been preparing the buildup of a biotechnology line--or are already in the market.

More than 2000 sake manufacturers, about 1,300 producers of soy sauce, and about 1000 instrument manufacturers--generally small businesses--regard biotechnological methods as an opportunity for conquering new market niches. A remarkable feature here is the readiness for diversification; thus, in the meantime 268 firms from such diverse business areas as pharmaceuticals, seed goods, paper, or energy, have established biotechnological research groups. For all that, the average staff complement is 19.2 staff members. Basic methods have here undergone a stormy development. In the "Biotechnology Development Corporation" BIDAC, called into life by MITI in 1983, 175 industrial enterprises have associated themselves for the following purposes:

- o for the joint development of methods
- o for the implementation of methods of training measures
- o for consultation in the promulgation of legal ordinances
- o for the collection of international information.

The great success of this measure has called other ministries into action. Thus, the efforts of the Ministry of Health have just about succeeded in associating 150 pharmaceutical enterprises in an analogous "Biotechnology Development Corporation".





1	1982 114 companies	2	1985 268 companies
3	companies	4	pharmaceutical
5	diagnostics	6	foodstuffs
7	agricultural chemicals	8	agriculture, guidance
9	seed goods	10	fisheries
11	chemistry, paper	12	energy
13	environment	14	bioelectronics
15	bioinstrumentation		
16	biotechnology projects in Japanese firms		
17	1982 114 companies	18	1985 268 companies
19	companies	20	gene technology
21	cell diffusion	22	cell culture technique
23	bioreactor	24	biomass conversion
25	computer-aided drug design		
26	biotechnological development of methods in Japanese companies		

*Not recorded in 1982

Source: Nikkei Biotech. 7 October 1985.

The Agricultural Ministry has gathered 45 enterprises of the foodstuff industry behind its colors. Topic: Biotechnological production of foodstuffs. The Construction Ministry is funding 13 corporations in the development of biological compact waste disposal systems.

In contrast to the Federal Republic, Japan offers a fertile soil for such ministerial initiatives. The following factors contribute to this:

- a culturally based inclination towards cooperation
- a readiness on part of many enterprises to diversify into new areas
- a tradition of long-term earning in business

Some examples ....

1. In 1971, the whiskey giant Suntory invested part of its profits in a biocenter, which belongs among the most sophisticated in Japan. Today Suntory has taken hold in wine cultivation, and has acquired vineyards in California, France, and the Federal Republic. Through the biotechnological development of "virus-free grapes", which can be pressed into more wine of higher quality, Suntory occupies a leading position in international wine research. Some of the gene-technological pharmaceutical research results of the center belong among the top accomplishments world-wide during recent years.

2. When the Japanese mail was privatized in April 1985, six billion yen of the proceeds (about 80 million DM) were applied to the construction of a "protein engineering center". Beginning in 1987, numerous corporations from the pharmaceutical, biological, and computer industry were to interact with one another here. The purpose was to accomplish "computer-supported synthesis of materials". During the next 10 years, this is supposed to lead to new pharmaceutical agents and technical biocatalysts. (The Japan Development Bank is likewise providing six billion yen for this; another six billion are supplied by the corporations themselves. Management: MITI.)

3. The feared minamata disease (mercury poisoning from the consumption of fish from the environment of the soda industry) led to the founding of an industrial association in 1974. Its goal was to convert the 35 Japanese soda factories to environmentally neutral production processes. For this purpose, one billion yen were paid into a fund by the affected firms, another billion yen was paid in by MITI. But the businesses succeeded very quickly in converting their production on their own. Thus, a fund of about 4 billion yen (loans plus interest) was available for new activities. The association--now reinforced by 43 more corporations from the petroleum-, foundry-, electrical-, and chemical-industry, now decided a few months ago to use the funds for building :p commercial data bases in the biotechnological area and other advanced technologies.

4. When questioned about the most important tasks of government research funding, 60 percent of the more than 100 questioned corporations replied: "The development of basic methods by means of research associations organized by government". Only 25 percent of the questioned corporations voted for tax measures.

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POTENTIAL SDI PARTICIPANTS EXAMINED

Tokyo SENTAKU in Japanese Jan 87 pp 98-100

[Excerpts] It already has been three months since the government decided to participate in SDI (strategic defense initiative) research. The industrial world of Japan is now watching with bated breath the direction of on-again, off-again deliberations between the U.S. and Japanese governments in order to create the framework for research participation.

The industrial world of Japan especially is taking note of the technology side of SDI. It is the unanimous opinion of those concerned that the technology level will need to be increased two to three orders over the present. "A rapid leap in the technology level of the United States is being planned through implementation of large-scale and wide-scope basic research under the SDI research program. If new technology should be created, the technology level of the United States would be at a level higher today than both the United States and Japan. It is believed that if Japan were to participate in the SDI research program in an appropriate form and by a method in which it will be able to make use of the results, there is a possibility it would have a great effect also on raising Japan's related technology level." (SDI Government and Civilian Joint Survey Team Report)

Even a sense of crisis has seeped out that the Japan of tomorrow based on science and technology truly depends on SDI and if it does not participate, it will be left behind in the technology revolution of the 21st century.

However, a division chief of a major electrical manufacturing firm which participated in the Government and Civilian Joint Survey Team has frankly expressed a warning that "The Reagan regime may flaunt a huge research and development budget and co-ownership of advanced technology created from research and development, but SDI itself is a high tech word upon which survival in the 21st century depends technology-wise. The aim of the United States is to reign over the world again in the area of advanced technology by concentrating Western high tech technology in the United States."

"There is a fear of being constrained. But there is a worse fear of missing the technology revolution." With complicated thoughts, the industrial world of Japan has concentrated its gaze on the progress of deliberations between the U.S. and Japanese governments which have had rough going.

Possibility of Immediate Diversion to Civilian Use

Simply speaking, SDI is the concept to intercept a nuclear missile, presumably a Soviet ICBM, and render it powerless by using leading edge technology such as laser and beam weapons placed on the ground and in space. Specifically, the intercept is divided into four stages: 1) the acceleration stage (boost) of several minutes after the enemy missile launch, 2) the post-boost stage of flight in space, 3) the intermediate flight stage until re-entry into the atmosphere, and 4) the final stage of entry into the atmosphere and meeting the target.

The five fields for research are 1) SATKA (search, acquisition, track and kill assessment), 2) KEW (kinetic energy weapon), 3) DEW (directed energy weapon), 4) SLKT (expansion unidentified), and 5) SC/BM (system architecture).

SATKA is the technology for missile early detection, identification and tracking, and search technology. The aim is to upgrade what corresponds to the so-called "eyes," such as laser radar, synthetic aperture radar, milliwave radar, infrared sensors, and phased array radar. If diverted to civilian use, radar technology would contribute to air control radar and remote sensing, infrared sensor technology to computers and a great improvement in information processing technology, in addition to medical and industrial measurements and small, high-efficiency coolers.

The KEW is a kinetic energy weapon such as a rail gun (electromagnetic gun) to shoot down missiles in space. There are, for example, HOE interceptors (a type of interceptor missile) and missiles aboard satellites. If these are diverted to civilian use, there are applications to linear motor cars and the power source for the necessary superconducting technology in nuclear fusion, manufacture of high quality alloys, and upgrading of metal processing technology in the rail gun field, and small, light-weight sensors, inertial devices, and processors in the missile intercept system field will play a role in the advance of aircraft and rocket technology.

The DEW is a laser/beam weapon group placed in space or on the ground to destroy missiles and warheads. There are, for example, chemical laser weapons, free electron laser weapons, neutron particle beam weapons, and X-ray laser weapons. These technologies can be applied to laser nuclear fusion, energy-related technology such as uranium enrichment, and chemical reaction processes.

The SLKT assesses the weaknesses of weapons systems such as attack missiles and development is centered on a nuclear reactor for space. The SC/BM is the basic design of various types of defense systems. The aim is the establishment of an assessment method. Technology development such as high performance processors, high density optical disks, and advanced information communications networks is necessary, and there are application fields in fifth generation computers and artificial intelligence.

In other words, there is no differentiation in SDI technology between military use and civilian use. All the leading edge technology gathered in the United

States for SDI development can be immediately diverted to civilian use. The statement of the aforementioned department manager of a major electrical machines manufacturer that "(One of the aims of SDI) is for the United States to reign over the world again in the field of advanced technology by concentrating Western high tech in the United States" is not altogether off the mark.

So, the questions are what fields of Japanese technology interest the United States, and what U.S. technologies attract the eye of Japanese industry?

The report indicates interest in 38 fields by the First and Third Research Centers of the Technical Research and Development Institute (TRDI) of the Japan Defense Agency (JDA) and 8 commercial companies such as Mitsubishi Electric and Nippon Electric. All are leading-edge technologies capable of promoting a better future as well as application to SDI. Three to six fields of technology are listed for each company and the considerable overlaps are conspicuous.

The technology fields by industry indicated in the U.S. Department of Defense report are as follows: Nippon Electric Company has field effect transistors (FET), milliwave and microwave monolithic IC's (integrated circuits), milliwave diodes, optico-electric engineering, large electron tubes for milliwave and microwave amplification, and optical fiber gyros; Hitachi has optical disks, semiconductor lasers, optical fiber technology, and high resolution TV cameras; Fujitsu has LAN (local area networks) and parts, milliwave doppler radar, infrared CCD (solid state image element) technology, and phased array antennas; Mitsubishi Electric has a 94 gigahertz missile seeker (tracking device) and milliwave elements, optical fire control devices, missile simulator electronic wave darkrooms, milliwave radiometers, and carbon dioxide lasers; Toshiba has gas lasers, microwave and milliwave semiconductor elements, satellite broadcast receiver devices, visible light CCD, gallium arsenide lasers for optical disks, and integrated light spectrum analyzers. Sharp has satellite broadcast receiver devices, visible light semiconductor lasers, and erasable high density optical disks; Sumitomo Electric Industries has gallium arsenide production technology, optical fiber communications and optical fiber gyros; Matsushita Electric Industrial has optical disks, various sensors, low loss/frequency high stability filter materials, frequency converters for satellite broadcast receivers, optical elements, and optical fiber communications.

These optico-electric engineering and milliwave/microwave technologies are all technologies in which Japan is the world leader and in particular, they are technologies for super important elements indispensable in SATKA and SC/BM.

In addition, the United States has taken interest in submicron lithography which is indispensable for making the next generation very very LSI (large-scale integrated circuits), image recognition technology, voice recognition and automatic translation, artificial intelligence, flat displays, ceramics, composite heat-resistant materials, rocket propulsion, CAD (automatic design using a computer), and robot mechatronics.

From 31 March to 9 April 1986, an SDI Government and Civilian Joint Survey Team comprised of managers from the Ministry of Foreign Affairs, Ministry of International Trade and Industry (MITI), JDA, and Science and Technology Agency (98 people) and 21 private businesses (46 people) was dispatched to the United States. This was the first time for private firms to participate in a survey.

Other than the name of Watanabe, North American Bureau Councilor, Ministry of Foreign Affairs, and the chair of the delegation, which was publicly announced, the names of the participating enterprises have not been revealed. The reason is that "After returning home, they would become targets of the Soviet Union and it would be disastrous if secret SDI information were leaked." However, since the Japanese technologies desired by the United States which were revealed in the aforementioned McCallum report and the corresponding technologies held by members of survey team going to the United States were announced, the companies and positions will be listed here based on confidential data without designating individuals.

Why Wait-and-See On Participation?

The participating companies are: Ishikawajima Harima Heavy Industries (three people from Aerospace Division Headquarters, Energy Division Headquarters, and Technology Research Center), NTT Electronics Technology (one executive), Oki Electric Industry (two people from Defense Operations Headquarters and investigation position), Kawasaki Heavy Industries (three persons from Aircraft Technology Headquarters), Kobe Steel (one person from Technology Development Headquarters), Sumitomo Heavy Industries (one person from Precision Division Headquarters), Sumitomo Electric Industries (three persons from Research and Development Division), Sony (one person from deputy directors), Daikin Industries (one person from Electronic Technology Research Center), Toshiba (three persons, two from Radio Communications Division Headquarters and one from Production Technology Research Institute), Toray (one person from Composite Materials Division), Nissan Motor (one person from Aerospace Division), Japan Aviation Electronics Industry (two persons from Navigation Instruments Operations Division), Japan Steel Works (two persons from Machinery Division Headquarters), Nippon Electric Co (four persons from administrators, Electronic Device Division, Radio Applications Division, and Guided Optico-electrics Division), Hitachi (four persons, two from Defense Technology Promotion Division, one each from Systems Research Institute, and Hitachi Research Institute), Fuji Heavy Industries (two people from Aircraft Technology Headquarters), Fujitsu (two people from Fujitsu Systems Institute), Mitsui Engineering and Shipbuilding (one person from Aerospace Development Office, Operations Headquarters), Mitsubishi Heavy Industries (four persons, three from Nagoya Aircraft Manufacturing Plant, Flight Body Technology Department, one from Electronics Technology Department), and Mitsubishi Electric (three persons from consultant, Kamakura Manufacturing Plant, Central Research Center Electric Technology Research Department, and director, Research Headquarters).

It is noteworthy that the large companies, Mitsubishi Heavy Industries, Nippon Electric Company, Hitachi, Toshiba, and Mitsubishi Electric, sent three or more technical experts (department head/section class). Analyzed by a Japan

Defense Agency official who has seen these participating members, "They are a mixture of three groups, the 'have' companies that possess independently the technology the United States wants, the 'not have' companies without technology to lose if they participate, and the companies who don't want to miss the bus."

It is further clear that the companies participating in the first SDI Government and Civilian Joint Survey Team and the titles of technicians up to department level completely coincide with the technologies in which the United States has indicated interest to Japan with regards to U.S.-Japan furnishing of weapons technology. Along with receiving an explanation of the SDI research program by U.S. Department of Defense personnel in Washington, the Government and Civilian Joint Survey Team divided into the three groups of SATKA, KEW, and DEW to make tours. The details are secret, but an executive of a company which participated in the Survey Team has related that "We learned with our own eyes that the United States is serious in aiming at the realization of 'super-high tech' on an order two or three times the present, and felt somewhat apprehensive. The U.S. explanation was intense and thoroughly exhausted me." The executive of another company has said, "Frankly speaking, Japan has considerable advanced technology. However, there also is technology which is quite staggering and great reference was made to this."

What merit is to be obtained from Japanese companies participating in SDI research? According to the opinions taken by JDA, MITI, and the Science and Technology Agency from the executives of 21 companies participating in the Government and Civilian Joint Survey Team, "Since the general electronic parts eyed by the United States and of which Japan can boast to the world -- gallium arsenide and semiconductor lasers, CCD, and milliwave elements -- already are exported to the United States, these will be an easy profit. The problem is that the applications range such as for variable wavelength, high output lasers is wide and the greatest concern is how to close the gap in the leading edge basic science fields in which Japan is behind. (Officer, JDA)

Summarizing the talk of interested parties, the focus of attention was the free electron laser (FEL). That is because FEL, which suddenly has been noted in SDI, has a wide field of applications from basic science to industrial and medical uses, and it is the focal point of development competition among various advanced nations, including the advanced technology development program of Europe (Eureka). The FEL is different from other lasers, and has the special feature that wavelengths can be freely changed. It is the top candidate for the ground placed laser weapon in SDI.

In Japan, the Science and Technology Agency has taken up "high output, variable wavelength lasers" as a research theme, and the Tokyo University Institute for Solid State Physics, the Institute of Physical and Chemical Research, and Osaka University are conducting basic research. The fact is, however, that there has been no success even in a stable oscillation with a minute output.

In Japan, the MITI Agency of Industrial Science and Technology's National Chemical Laboratory for Industry (Tsukuba, Ibaraki Prefecture) is proceeding with development with the objective of using a rail gun in the development of

new materials. The aim is to increase dramatically development of new materials, space developments and nuclear fusion research using the impact compression phenomena generated when bodies hit a target at high speed. It is said that private companies such as Japan Steel and Sumitomo Heavy Industries have paid many visits to the National Chemical Laboratory.

However, the rail gun of the National Chemical Laboratory only has succeeded barely in driving an object weighing four grams at 2.3 km per second.

Actual Method of Participation = "Procurement"

As has been stated so far, according to what has been made public so far, the United States is seeking the participation of Japan chiefly in electronics-related technology, which is the forte of Japan. Japan is taking a wait-and-see policy, seeking technology in the leading-edge basic science fields in which Japan is weak, such as high output lasers.

However, the matter is not proceeding that simply. The government has decided on participation by the West German method with private enterprise as the main body and is attending discussions with the United States that should ensure it benefits on par with West Germany. It is said that there is a great gap, however, between what is advocated by the United States. The reason is that the four countries which already have signed memorandums of agreement with the United States for participation in SDI research, Great Britain, West Germany, Israel, and Italy, all have military secrets protection agreements with the United States. Only Japan does not have that agreement. To such a Japan, the United States cannot teach SDI core technology or handout new research results on par with West Germany and the other nations.

They want Japanese technology. However, the U.S. dilemma is that they cannot give the results of SDI. It is anticipated from this situation that nominal joint research will be conducted to indicate unity of the West, but the United States will independently do the core portion of research and development. So the actual method of Japanese participation will be by "procurement."

Three types of procurement are supposed -- 1) purchase of general parts and products from existing technology; 2) orders incorporating research and development expenses for upgrades; and 3) onerous cooperation by Japanese companies in the research and development of U.S. companies. The merits of "procurement" are that it is not necessary to inform Japan of SDI use, the basis of orders can be in the form of one private firm ordering from one Japanese private firm, not by the Department of Defense, and not be any different from general trade. The weak point of no military secrets protection agreement can be surmounted and it is in fact a practical method.

However, it is an obvious fact that there are parties concerned who say that what has been stated so far is "an unreliable account of the Japan side." These interested parties explain the extent of U.S. self confidence. "Foreign nations, particularly Japan, will not be able to get near the core portion of SDI at all. And it probably would be difficult even for Japan to approach it with technology cooperation. There is no suggestion that the United States will depend on the technology of allies. Intercept from the ground already

has fully taken shape." Together with the previously cited boosts of the head of the SDI office, it is rather persuasive.

At any rate, a judgment as to the form of participation in SDI or whether there can be other methods besides procurement still cannot be made. However, this month (January 1987), as the first application of the U.S.-Japan agreement to furnish weapons technology, the JDA/Toshiba developed portable TANSAM (short-range surface-to-air missile) tracking guidance device will be furnished to the United States.

Participation in SDI already has begun.

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ASDF TO SELECT AFCS IN JUNE

Tokyo AEROSPACE JAPAN-WEEKLY in English 13 Apr 87 p 1

[Text] The Air Self-Defense Force (ASDF) plans to purchase the first set of a new Automatic Flight Check System (AFCS) at about ¥900 million under the FY 1987 budget.

For the new AFCS purchase, ASDF has already sent requests for proposals (RFP) to four electronics manufacturers both at home and abroad, including Furuno Electric, Co., Gull Inc., Litton Systems Canada Ltd., and Sierra Research Corp.

The four companies are required to submit their proposals to ASDF by April 25. Based on the proposals, ASDF will finalize the new AFCS selection by the end of June. The new AFCS will be installed on the YS-11.

With a view to improving flight inspection systems, ASDF plans to purchase the FC-X new flight checkers under the FY 1986-90 Medium-Term Defense Buildup Program (MDBP). Before purchasing new flight checkers, ASDF will modify two out of the eight YS-11 turboprop transports now operated by ASDF's Air Transport Wing for flight inspection missions.

The new AFCS to be purchased in FY 1987 will be installed on the two modified YS-11s.

The FC-X program calls for purchasing off-the-shelf business jets on market and modifying them into flight checkers. ASDF plans to buy three to six aircraft for modification.

The FC-X will replace the currently operational Mitsubishi MU-2 flight checker. The candidate aircraft include the Mitsubishi MU-300 (Diamond II), the Cessna Citation II/III, the Falcon 900, the Canadair Challenger 601, and Gulfstream III/IV.

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CSO: 4307/018

DOMESTIC FS-X MAY COST ¥6 BILLION

Tokyo AEROSPACE JAPAN-WEEKLY in English 13 Apr 87 pp 2-4

[Text] A joint study group formed by five major Japanese military manufacturers, including Mitsubishi Heavy Industries, Ltd. (MHI), has worked out a domestic development plan for the FS-X next support fighter of the Air Self-Defense Force (ASDF).

According to the plan, it is estimated to cost about ¥6 billion to manufacture a domestic FS-X fighter aircraft which completely satisfies ASDF's requirements. This includes the development cost too.

The domestic FS-X is expected to be cost-competitive enough against the aircraft proposed by two American aircraft manufacturers, according to the study group. With this plan, the Japanese aircraft manufacturers are expected to refute the U.S. claim that domestic FS-X development would cost higher.

For the FS-X selection, ASDF was briefed by General Dynamics (GD) and McDonnell Douglas (MD) on their respective FS-X joint development proposals from late March through early April. This will be followed by briefing by Japanese manufacturers on the domestic development plan.

Although neither of the companies concerned are required to show cost estimates, the Japanese manufacturers worked out the cost estimate to prove that the domestic FS-X is cost-competitive against the aircraft proposed by GD and MD.

Among the member companies of the joint study group, MHI, Kawasaki Heavy Industries, Ltd. (KHI) and Fuji Heavy Industries, Ltd. (FHI) are in charge of the airframe of the FS-X, while Ishikawajima-Harima Heavy Industries Co., Ltd. (IHI) and Mitsubishi Electric Corp. (MELCO) are responsible for the engine and the avionics respectively, according to the plan.

In terms of cost, the airframe accounts for 50%, the avionics for 30% and the engine for 20%. The avionics seem to have relatively a large share in developing the domestic FS-X.

The FS-X procurement will start around 1995. ASDF is expected to procure a total of 100 aircraft or more. The joint study group believes that the domestic FS-X plan will not suffer negative influence of temporary appreciation of yen against dollar.

The study group also pointed out that the proposed American aircraft are anticipated to cost higher in a long run because of inflation in the U.S. Even if the value of yen continues to stand at a 1$ = ¥150 level, the domestic FS-X will remain cost competitive enough, according to the study group.

As for the powerplant of the domestic FS-X, the study group will propose one of the following three candidate engines: General Electric's F404, Pratt & Whitney's PW1127 and Turbo Union's RB199.

No matter what engines should be selected, Japan will produce the engine under license. But domestic technology may be applied partly to the engine such as a two-dimensional nozzle.

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CSO: 4307/018

NDPO ALLOWS JAPAN TO PREPARE FOR OCEAN AIR DEFENSE

Tokyo AEROSPACE JAPAN-WEEKLY in English 13 Apr 87 p 4

[Text]

Defense Agency Director General Yuko Kurihara said at a budget committee of House of Councilors on March 31 that although the National Defense Program Outline (NDPO) does not touch upon "ocean air defense," Japan is allowed to introduce new military equipment for this purpose in order to cope with changes in international affairs.

He said that NDPO is designed to be flexible to cope with military affairs around Japan and ocean air defense is included in this policy to cope with changes of circumstances.

JDA's Defense Policy Bureau Director General Seiki Nishihiro supplemented Kurihara's view as saying that the Maritime Self-Defense Force (MSDF) is primarily responsible for safeguard of sealanes. So, MSDF has to counter such threat as submarines, mines and aircraft too to protect sealanes. Japan has considered ocean air defense ever since establishment of MSDF, Nishihiro said.

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CSO: 4307/018

MSDF ORDERS FIRST KM-2 KAI PRIMARY TRAINER

Tokyo AEROSPACE JAPAN-WEEKLY in English 13 Apr 87 p 5

[Text]

The Maritime Self-Defense Force (MSDF) will start procurement of the KM-2 Kai primary trainer which was developed by Fuji Heavy Industries, Ltd. (FHI), under the FY 1986 aircraft procurement program. MSDF recently placed an order with FHI for the first aircraft at ¥236.5 million. The aircraft is scheduled for delivery in August 31, 1988.

The KM-2 Kai was developed by FHI to replace the currently operational KM-2 piston-engine primary trainer. It is powered by the Allison 250-B17D (420 s.h.p.) engine. The side-by-side-seat trainer is equipped with a large bubble canopy like the Fairchild T-46A.

Designated as the prime contractor in May last year, FHI has already started the KM-2 Kai production with a view to delivering the aircraft at the end of August 1988. It will start assembly of the aircraft in October this year.

The roll-out is scheduled in February 1988. After ground tests, the aircraft is due to make its first flight in late April. After flight tests by FHI for about four months, it will be delivered to MSDF at the end of August for further tests by MSDF's Air Development Squadron 51 at Atsugi Air Station.

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CSO: 4307/018

TRDI DEVELOPING TWO NEW MISSILES FOR MSDF

Tokyo AEROSPACE JAPAN-WEEKLY in English 13 Apr 87 pp 5-6

[Text]

The Technical R&D Institute (TRDI) is now developing two types of new anti-ship missiles for the Maritime Self-Defense Force (MSDF). One is the XSSM-1B ship-to-ship missile and the other is the XASM-1C air-to-ship missile.

The XSSM-1B is a derivative of the XSSM-1 surface-to-ship missile now being developed for the Ground Self-Defense Force (GSDF). The XASM-1C is an air-launch missile derived from the XSSM-B by removing the booster.

XSSM-1B. This missile will be developed under a three-year program from FY 1986 through FY 1988. TRDI recently contracted prototype fabrication of the missile to Mitsubishi Heavy Industries, Ltd. (MHI) as the prime contractor at ¥2,506.4 million. The delivery is scheduled on September 30, 1988.

This missile is a modification of the XSSM-1 which is being developed by TRDI for GSDF. It is designed to use the same fire control system and the launcher of the UGM-84 Harpoon's.

XASM-1C. This missile is a new air-breathing type air-to-ship missile to replace the Type 80 ASM-1 missile. TRDI has set aside some ¥3,360 million for prototype fabrication of the missile under the FY 1987 budget with a view to developing it in time for deployment starting in 1990.

The XASM-1C is a modification of the XSSM-1B. It will be launched from the Lockheed P-3C anti-submarine patrol plane. It will also be designed to use the same fire control system as the AGM-84 Harpoon's. Since it will be installed at the Harpoon launcher pylon of the P-3C's outer wing, the fin of the XASM-1C will be smaller than that of the XSSM-1B.

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CSO: 4307/018

FS-X JOINT DEVELOPMENT PROPOSAL

Tokyo AEROSPACE JAPAN-WEEKLY in English 20 Apr 87 p 1

[Text]

McDonnell Douglas (MD) started on April 6 briefing the Defense Agency (JDA) and the Air Self-Defense Force (ASDF) on details of its joint development proposal for the FS-X next support fighter.

The briefing was given by a 21-man team headed by James P. Caldwell, Vice President-Marketing of McDonnell Aircraft Company. The team consisted of 12 executives from MD and three each from Northrop, General Electric and Hughes Aircraft.

MD has reportedly proposed four types of modifications of the F/A-18 fighter aircraft to satisfy ASDF's requirements for the FS-X. The briefing was held for two or three days, according to industry sources.

On the other hand, General Dynamics (GD) also briefed on its joint development proposal a week earlier than MD. GD proposed a twin-engine version of the F-16.

Following the two American aircraft manufacturers' briefing on their respective joint development proposals, JDA discussed the FS-X issue with an expert team of the U.S. Department of Defense (DoD) which visited Japan on April 11 for about a week with a view to seeking appropriate data and information for the aircraft selection.

JDA will also be briefed late this month on a domestic FS-X development plan by a joint study group which was formed by five major Japanese military manufacturers, including Mitsubishi Heavy Industries, Ltd.

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CSO: 4307/017

MHI TO DEVELOP SIMULATOR FOR NEW TANK

Tokyo AEROSPACE JAPAN-WEEKLY in English 20 Apr 87 pp 1-2

[Text]

Under a contract from the Defense Agency (JDA), Mitsubishi Heavy Industries, Ltd. (MHI) will develop a firing training simulator for the TKX next-generation battle tank which is expected to be deployed in the 1990s.

The new tank program has already entered the second phase prototype fabrication stage. Using Japan's advanced electronic technology, it will be equipped with computers, sensors and laser range finders.

To operate such a sophisticated tank, the crew will have to be well trained and operational skills will have to be maintained too. For this purpose, JDA needs a simulator for the tank operation and firing training. It will be the first time to use a simulator for tank operation training in Japan.

The new tank will be armed with a 120mm smooth-bore gun to be supplied by Rheinmethall of West Germany. And it will be equipped with a digital computer, various sensors for environmental detection and an advanced laser range finder.

As the new tank will adopt a self-loading system, the number of the crew members will be reduced to three. Adoption of various new technology is one of the reasons for the simulator development.

JDA and MHI will also start development of a new tank recovery vehicle and a self-propelled tank bridge, using the same hull as the new tank's.

Compared with the Model 74 main battle tank (about 40 tons in weight, 720 h.p. engine and maximum driving speed of 53 k.p.h.), the new tank weighs about 20% lighter and its speed reaches 70 k.p.h. because of a 1,500 h.p engine. Because of such a high maneuverability, the current support systems for the Model 74 tanks will be all replaced.

JDA's Technical R&D Institute (TRDI) is given ¥3,600 million for the simulator development under the FY 1987 budget. The simulator for such a high-tech tank is expected to be very expensive because of many advanced technology items, including a computer, visual and acoustic systems and a precise attitude control system.

For the currently operational Model 74 tanks, JDA uses no simulators. The crew training is done in actual operation.

The new tank was initially called Model 88 tank. JDA had expected to procure the new tank around 1988. But the development has been delayed primarily because of selection of the smooth-bore gun.

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CSO: 4307/017

TOP FY '86 DEFENSE CONTRACTORS

Tokyo AEROSPACE JAPAN-WEEKLY in English 20 Apr 87 pp 8-9

[Text]

The Defense Agency (JDA), according to just released figures from its Central Procurement Office, contracted a total of ¥1,199.6 billion to the domestic defense industry in FY 1986, which ended on March 31, 1987, ¥48 billion more than the previous fiscal year. The top ten companies, in terms of total monetary amount contracted, accounted for about 66%.

Mitsubishi Heavy Industries, Ltd. (MHI), uncontestedly Japan's largest defense supplier, topped the list with ease as it has for many years.

The most remarkable jump was made by Mitsubishi Corp., which ranked below 50th position in the previous fiscal year, because of four MH-53E minesweeping helicopters. Instead, Sumitomo Heavy Industries, Ltd., which ranked eighth in the previous fiscal year, dropped from the top ten list because of no contracts for destroyers.

Major items contracted in FY 1986 include a set of the Patriot surface-to-air missile system (¥94.9 billion), 12 F-15 fighter interceptors (¥74.4 billion) and ten P-3C anti-submarine patrol aircraft (¥48.3 billion). The top ten defense contractors are as follows:

- Unit: ¥ 100 million -

Company	Amount	Prev. Rank
1. Mitsubishi Heavy Industries Ltd.	2,914	1
2. Kawasaki Heavy Industries, Ltd.	1,448	2
3. Mitsubishi Electric Corp.	813	3
4. Ishikawajima-Harima Heavy Industries Co., Ltd.	782	5
5. Toshiba Corp.	674	4
6. NEC Corp.	485	6
7. Nippon Seiko Co., Ltd.	222	7
8. Fuji Heavy Industries, Ltd.	182	10
9. Hitachi Shipbuilding & Engineering Co., Ltd.	182	9
10. Mitsubishi Corp.	170	-

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BRIEFS

F-15 EQUIPMENT--The Defense Agency (JDA) plans to equip the F-15 fighter interceptor with the ALQ-8 new ECM (electronic countermeasure) system, beginning in 1988. JDA will also start a one-year flight test program of an active phased-array radar aboard a C-1 transport in April this year. Both the ALQ-8 and the new active phased-array radar are developed jointly by JDA and Mitsubishi Electric Forp. (MELCO) with purely domestic technology alone. In particular, the active phased-array radar is the first to be developed in the world. JDA expects to apply these technologies to the FS-X next support fighter too. [Text] [Tokyo AEROSPACE JAPAN-WEEKLY in English 13 Apr 87 pp 4-5] /8309

CSO: 4307/018

IMPORTANCE OF SECURING RARE METALS DISCUSSED

Tokyo NIKKO MATERIALS in Japanese Dec 86 pp 14-18

[Article by Akira Fujisaki, Federation of Economic Organizations (Keidanren), Resource Planning Committee Chairman]

[Excerpt] Naturally Existing Amount of Rare Metals Is Extremely Small

Speaking generally about rare metals: 1) the amount of natural rare metals is small; 2) a very small amount of rare metals is contained in minerals, and it is economically difficult to gather these rare metals from the minerals; 3) it is technically difficult to extract the rare metal as a pure metal. Rare metal means a metal other than iron, or nonferrous metals, such as aluminum, copper, lead, zinc, of precious metals such as gold or silver, existing in the earth's crust.

The kind of minerals is shown below in accordance with data prepared by the Fiscal 1986 Mining Industry Council in relation to the storage of these minerals as a mineral resource policy.

a) Seven minerals presently being stored are nickel, chromium, tungsten, cobalt, molybdenum, manganese, and vanadium.

b) Eight minerals in which it is anticipated that the demand and storage need will increase in the future, are niobium, palladium, strontium, tantalum, platinum, titanium, zirconium, and rare-earth.

c) Fourteen minerals in which the necessity for storage even in the future is low from the standpoint of structure of demand and supply, are as follow-: 1) two minerals in which overseas dependence is low, are germanium and selenium, 2) two minerals in which the productive unevenness is low, are antimony and barium, 3) twelve minerals whose market scales are small, are lithium, berryllium, gallium, boron, rubidium, indium, tellurium, cesium, hafnium, rhenium, thallium, and bismuth.

Of the above 31 minerals, rare-earth has 17 elements consisting of two elements, i.e., yttrium and scan dium and 15 elements with atomic numbers from 57 to 71 shown in a periodic table. Accordingly, the total number of elements is 47.

Rare Metal Resource Serving and Producing Country

One of the most important features of rare metals is that the resources of these rare metals are uneven and they are produced by specific countries.

There is a possibility of the unevenness and specification causing political, economical, and social disturbances and rare metal-supply interference due to wars, and this possibility will cause weakness in the rare metal-supplying structure. Industrially-advanced countries which will increase the amount of rare metals consumed in the future, must urgently take measures against this serious problem. Nineteen minerals consisting of 7 minerals mentioned in item a), 8 minerals mentioned in item b), antimony, germanium, selenium, and barium, have a relatively large market demand scale. Total deposits of the 19 minerals from three high-ranking countries account for more than 50 percent, and the total amount of the 19 minerals produced by these countries is also more than 50 percent. In the extreme case, some of the three countries account for 99 percent. In other words, these minerals are unevenly distributed within the three countries. Minerals whose total deposits are less than 50 percent are antimony, ilmenite, and barium whose total production quantity is less than 50 percent. This can be cited as an exception.

Particularly, one of the most significant features of rare metals is that the production of these rare metals are one-sided in favor of a small number of specific countries. For example, about 60 percent of chromium, manganese, and vanadium are produced by South Africa and the Soviet Union, and 60 percent of cobalt is produced by Zaire and Zambia. Also, it is anticipated that the demand for niobium, palladium, and platinum will increase together with the innovation of high-technologies in the future. In this situation, 82 percent of niobium is produced by Brazil, and more than 95 percent of palladium and platinum are produced by the Soviet Union and South Africa. In addition, it is expected that rare-earth will be widely used as a functional material. Although such rare-earth has not yet been produced, China has 80 percent of its deposits. As a matter of course, the rate of Japanese dependance on these imported rare metals is high, being almost 100 percent, except for selenium (5 percent) germanium (42 percent), and tungsten (79 percent). It is necessary to take great interest in this fact.

Demand Increases Steadily

There are two methods of using rare metals. One is as a functional material such as semiconductor material, magnetic material, optical material, etc., or in various alloy steels including stainless steel, and the other is in accordance with future needs, i.e., in new fields such as information-oriented society, space, and ocean.

a) Rare Metals Which Have Already Been Used

The rare metal is used as an adding element for steel, and is indispensable as a functional material in various industrial fields. Particularly, it is an indispensable additive for so-called, special steels such as structural steel, tool steel, etc.

According to the 1984 Japanese Statistical Data, the rate of rare metals used for special steels is as follows: tungsten (20 percent), cobalt (23 percent), nickel, chromium, vanadium, and manganese (80 to 90 percent), respectively. These rare metals are also used in new technology-products such as magnets, magnetic material (VTR: video tape recorder), catalyst, IC (integrated circuit) lead frame, battery, etc.

b. Rare Metal As a New Material

The need for new metallic materials has increased in proportion to the progress in research and development of high technologies. In December 1984 the Mining Industry Council Mine Committee Rare Metal Policy Planning Special Subcommittee made a report on such new metallic materials. According to this report, the new metallic material must meet functional conditions such as super-conductive characteristics, semiconductive characteristics, magnetic characteristics, nuclear characteristics, etc., in addition to conventional structural conditions. The resource indispensable for the new metallic material is a rare metal. Also, research and development of characteristics of the rare metal itself as a new material are being conducted enthusiastically. In addition, it is expected that the demand for rare metals will increase from now on, because they can be used as metallic materials or as composite materials of fine ceramics and high polymer chemicals. It is considered that future high technology industries will promote the discovery and development of new characteristics of rare metals, and this discovery and development work will cause the exploitation of new fields in these high technology industries.

Market Scale for New Materials Will Be ¥5.4 Trillion on 2000

According to the Industrial Structure Study Meeting held in March 1984, the market scale for new materials will be ¥5.4 trillion and that of relevant markets will be increased more than 10 fold in 2000. It seems that the market for rare metals will increase sharply together with the progress of this tendency, but considering the fast technical innovation, shortness of material life cycle, increase in opportunities for replacing materials with each other, etc., it is extremely difficult to anticipate the demand for rare metals. The report anticipates this demand in the form of Table 2.

Measures for Ensuring Stable Rare Metals

As clearly shown in the uneven concentration of rare metal resources, the rare metal supplying structure is extremely weak. Nevertheless, not only Japan, but also European advanced countries are successively contemplating their businesses to resource rich countries on the basis of intermediate and long-term views, and are enthusiastically mining and developing rare metals with the aim of establishing a rare metal supplying system because a rare metal supply structure is indispensable for the development of future high technology industries. Particularly, in the case of two or three countries in Europe, the government has a powerful policy, and is obtaining results in deepening friendships with resource rich countries through the supply of technology, capital, and manpower.

Table 1. Examples of Rare Metals With New Uses as High-Technology Materials

Name of mineral	Future demand
Gallium	Excellent semiconductor characteristics according to compounds of As and P, laser light emitting characteristics, VLSI (very large scale integrated circuit) light emission, and diode
Niobium	Alloy of Sn, Ti, etc., has excellent superconductive characteristics. Application of NMR-CT (nuclear magnetic resonance computer tomography), nuclear magnetic resonance computer diagnosing medical equipment, linear motor car, and nuclear fusion reactor
Rare-earth	Light emitting devices, ceramic capacitor, ultra-high performance magnetic laser with magnetic characteristics, laser light emitting characteristics, and high inductive characteristics, etc.

Table 2.

	Present status	As of 2000	Magnification
	¥10 trillion	Y10 trillion	
For new materials	3.5	53.6	15.3
For existing fields	55.1	116.1	21.
Total	58.6	169.7	2.9

(Note) Magnification per mineral

Gallium : 100 fold
Indium : 100 fold
Niobium : 40 fold
Germanium : more than fivefold
Rare earth : more than fivefold
Nickel : threefold
Cobalt : threefold

In the case of Japan, the government well understands the present status of rare metals, but is behind that of European countries in actual action. Also, there are some enterprises for nonferrous metals, which will be able to carry out the work of mining and developing rare metals. Regrettably, the power of these enterprises has decreased, and particularly it has decreased sharply due to the yen valuation since the G-5 (finance ministers and central bank governors of the Group of Five major countries) Meeting held last year. Therefore, at present, these enterprises are in a situation where they can hardly set about mining and developing rare metals.

For this reason, it cannot be said that the Japanese Government has obtained satisfactory results about friendship with resource rich countries and maintenance and improvements of other relations with them. It is anticipated that once the demand and supply of rare metals get stringent, this stringency may bring about a situation such as supply-cut.

Anxiety About Interference With Supply

The Japanese GNP slightly surpasses 10 percent of the world and the consumption of base metals and nickel and cobalt which have been used in Japan is 15 to 20 percent of the metals used in the free world. That is, Japan has an industrial structure with high metallic consumption. The industrial structure is changing, but high technology industries are increasing the demand for rare metals for new materials. This tendency will not change from now on.

As previously mentioned, rare metals are unevenly and concentratedly distributed in the Soviet Union, South Africa, and the Central African countries. Judging from this fact, it is believed that anxiety over the supply of rare metals will be caused by the following items: 1) stop of supply of rare metals, based on the political tensions caused by the relationship between the Eastern and Western worlds, 2) measures from an embargo on export of rare metals, caused by wars between South Africa apartheid and neighboring countries, 3) stop of supply of rare metals, caused by wars between two countries or domestic conflicts, caused by confrontations between tribes, peculiar to African countries, 4) conflicts caused by North-South problems, non-aligned country conferences, and activities of OAU (Organization of African Unity), ANC (African National Conference), etc.

It cannot always be said that the probability is strong, because the situations mentioned in the above items are a serious blow to both Northern and Southern countries. However, there have been a few examples in the past.

The export of cobalt from Zaire was embargoed for two months, because the Second Shaba War broke out in the country in 1978. (This war was caused by the conflict between tribes of Angola and those of Zaire.) Therefore, the price of cobalt rose sharply six fold, and Japanese users could not avoid making desperate efforts to obtain cobalt. This incident is fresh in our memories.

Also, Angola and Mozambique became independent of Portugal in 1975. It is well known that this independence was supported by the Soviet Union and Cuba, and it is considered that the following possibility may have become a historical hypothesis. That is that a Soviet Corridor has been formed in Central Africa (Zimbabwe, Zambia, and Zaire) which geopolitically connects both countries.

Recently South Africa has suggested an embargo on exports of chromium, manganese, vanadium, platinum, etc. If this kind of situation occurs, it will be uncertain as to what problems will occur. The following calculation is based on slightly old data. That is, when the amount of chromium and nickel annually required is reduced by 30 percent, the GNP rate will go from minus 4.8 to minus 4.4 percent, and exports will go from minus 22.6 to minus 20 percent, respectively. The reduction in supply of rare metals will promote a conversion in the industrial structure and will have a considerably large influence on various fields.

Exploration of Rare Metals and Development of Technologies for Extracting, Refining, etc., These Rare Metals

In order to overcome the weakness of the supply structure of rare metals, diversify the supply source of these rare metals, and cope with the change of the future demand for them, it is necessary to explore them and develop technologies for recovering and refining them.

As previously mentioned, the resource of rare metals is unevenly distributed in the specified countries. This means that the supply source is restricted. Also, the rare metal has the aspect of strategic goods, because it is a material indispensable for high technology industries. Therefore, from the standpoint of economic security, it is extremely important to ensure the supply. It is necessary not only to invest money in the supply of rare metals, but also to make efforts to reinforce the interdependence and friendship with resource-rich countries through manpower, goods, and technologies.

The exploration of marine mineral resources such as manganese nodules, hydrothermal deposits, and cobalt rich crafts as well as land resources will probably be developed in the future. In order to do so, it is desirable to make preparations for technical cooperation in foreign countries, obtain bargaining power for ensuring resources, and accumulate technologies by giving actual results of the most stable domestic resources.

Briefly mentioning the data reported in the subcommittee, Japanese mineral deposits which may contain rare metals are the pegmatite mineral deposit, contact metamorphism mineral deposit, vein mineral deposit, black mineral deposit, etc.

Difficulties in carrying out the exploration work are as follows: 1) it is difficult to narrow rare metals down to the developmental target due to a market risk in which it is difficult to anticipate the long-term demand for rare metals, because of shortness of life cycle, etc., such as progress in alternative metals, caused by technical advancement, 2) there are cooperation-hindering factors caused by differences in political systems and country risks

peculiar to developing countries (resource-rich countries), 3) compared with nonferrous metals and uranium, rare metals have been explored little and the number of accumulated technologies for exploring rare metals is very small, 4) roughly speaking, the rare metal reserves are also small, 5) new and advanced-technologies for gathering and extracting rare metals are required under a condition in which these rare metals are low-grade minerals.

Next, considering the ideal way of the overseas development work, first Japan must make efforts to develop basic technologies and enhance their levels through the domestic development of stable supply sources. In order to continue and develop the status of advanced-high-technology industries, she must positively develop the exploration work regardless of the above mentioned difficulties in foreign countries, even if these foreign countries are risky in respect to this exploration work. It is believed that this matter is the central subject for ensuring the resource of rare metals.

However, it cannot always be said that compared with measures taken by EC (European Community) countries, those taken by Japan are sufficient in respect of the government guided-environmental maintenance for ensuring overseas resources. For example, the MMAJ (Metal Mining Agency of Japan) has domestically reduced the degree of risk of exploration work at the initial stage, and has fully exercised its function by offering information guidelines necessary for efficient performance. Therefore, it is desirable to complete and reinforce the exploration work also in foreign countries.

Also, the combination with ODA (Official Development Aid) and JAICA should be considered. Japan has excellent geophysical and chemical exploring technologies, and can compete favorably with other advanced-countries in those technologies. Although the power of Japanese resource industries has decreased sharply, it is considered that if they have the necessary conditions, there is a strong possibility that they will play an important role in ensuring rare metal resources in foreign countries.

Important Technical Development

In order to cope with the increase in demand for rare metals and the qualitative change of these rare metals, it is absolutely necessary to raise the level of technologies for extracting, smelting, and refining rare metals. Some people anticipate that the rare metal industry will be the support and driving force of the next-generation's technical innovations in a sense whereby the rise of these technologies is useful for increasing the range of application for rare metals.

The contents of a report on developmental subjects related to rare metals, made by the subcommittee are as follows: 1) technology for extracting small amounts of metals was developed with a view of exploiting small-scale mineral deposits of floating beneficiation metal and investigating the rare metals and the local physicochemical phenomena caused by low grade rare metals. 2) a comprehensive process is developed by combining a process for the reformation of mineral properties and a process for particular surface treatment in addition

to various processes such as the comprehensive concentration process specific gravity concentration, magnetic concentration, electrostatic separation, etc., 3) with regard to smelting technology, a wet smelting method is studied so that it can be used for tantalum, gallium, and rare-earth, 4) although solvent extraction, ion exchange resin, and chelate resin can be cited as some of the examples, a method for separating physicochemically similar rare metals was developed. In order to realize the above items, an efficient developmental system must be taken on the basis of industrial, educational, and governmental cooperation.

Increasing Necessity of Storage

Up to now, I have advocated methods of tackling exploration work for resources of rare metals in foreign countries from the standpoint of the Japanese comprehensive security. This is because these methods should not be entrusted to the managerial judgment of an enterprise from the long-term standpoint, but should be regarded as urgent and long-term subjects. Considering resources from this standpoint, the global demand and supply will bring about prosperity in both resource-rich and resource-consuming countries, even if the resources are unevenly distributed in specific areas. However, it is difficult to deny the fact that there is a possibility of a short resource supply caused within a short period of time. It is necessary to separately take measures against such a situation, and it is desirable to keep a fixed quantity of resources in preparation for unforeseen accidents such as tightening, hindrance, etc.

Of course, it goes without saying that the storage of resources should be decided from the standpoint of national comprehensive security with consideration to political, diplomatic, defensive, industrial, and economic policies. In addition, arguments for deciding this storage should be made by persons widely concerned in various worlds as well as those concerned in the only resource industrial world, and storage should be judged on the basis of opinions summarized by these persons. However, in order to ensure the stable supply of rare metals which will become important keys for advanced-high technologies which will support the Japanese next-generation, would it not be necessary to urgently consider political means for exploration work and storage of resources?

Definite contents of policies for storing resources should be reviewed flexibly in compliance with the change of international environments, the direction of Japan's structural arrangements, and the status of Japan's international standing. Accordingly, it is considered to be not so important to be thoroughly discussed at the present time.

With regard to the present storage status of rare metals in Japan, she has been storing seven minerals, i.e., nickel, chromium, manganese, tungsten, cobalt, molybdenum, and vanadium since October 1983 in three forms, i.e., national storage, government and private joint storage, and private storage with the aim of storing these minerals for 60 days by 1987. The amount of minerals which have been stored up to the end of 1986 is for less than 27 days, and is valued at less than ¥26 billion, due to the restriction of finance reconstruction.

Briefly mentioning the rare metal storing status of the Western advanced countries while referring to Japanese examples, the United States is a great military country, and the amount of minerals stored in the country for a free nation is huge. That is, importance is attached to her national defense, and she has stored enough minerals to support her for at least three years in an emergency.

The United States has stored 31 kinds and 60 articles out of the 62 kinds and 92 articles of rare metals as of the end of September 1985. This storage is valued at $10 billion (less than ¥1.6 trillion) out of the targeted value, $16.6 billion. Of the EC countries, Sweden has stored enough minerals including rare metals to support her for a year in an emergency, and has stored for more than two months, minerals used for industrial purposes at peacetime. The amount of these minerals is valued at about $100 million.

Details are omitted. West Germany has stored minerals equivalent to $300 million, and France has stored those equivalent to about $400 million. England has stopped storing minerals due to financial reasons. Considering the actual status of the population, GNP, demand market scale, advancement of industrial structure, it seems that Japan has stored a very small amount of minerals compared with advanced countries other than the United States. Again may I say, there were many unexpected cases in which rare metal supply hindrance was caused by unforeseen accidents in the past. However, as the proverb says, "The danger past the God forgotten," persons other than those in authority are liable to forget these cases, and there is no doubt that it will be increasingly necessary to take measures for ensuring the stable demand and supply of rare metals in the future. In addition, it is never easy to carry out exploration work and enhance the technology levels for the purpose of ensuring a stable demand and supply of these rare metals.

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